USE AND DESIGN OF ACCELERATION AND DECELERATION LANES IN INDIANA

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by
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Technical Paper

USE AND DESIGN OF ACCELERATION AND DECELERATION LANES IN INDIANA

TO: K. B. Woods, Director
Joint Highway Research Project

January 30, 1963

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 8-4-22
Project: C-36-17V

Attached is a paper titled "Use and Design of Acceleration and Deceleration Lanes in Indiana" which has been authored by Heddy Jouzy, formerly of our staff, and H. L. Michael. The paper was presented at the 1963 Annual Meeting of the Highway Research Board in Washington, D.C., on January 11.

The paper is a summary of the research performed by Mr. Jouzy under the direction of Professor Michael which was presented to the Board several months ago. It is proposed that the paper be offered to the Highway Research Board for publication.

The paper is presented to the Board for the record and for approval of the proposed possible publication.

Respectfully submitted,

Harold L. Michael

Harold L. Michael, Secretary

HLM/lkc

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File: 8-4-22
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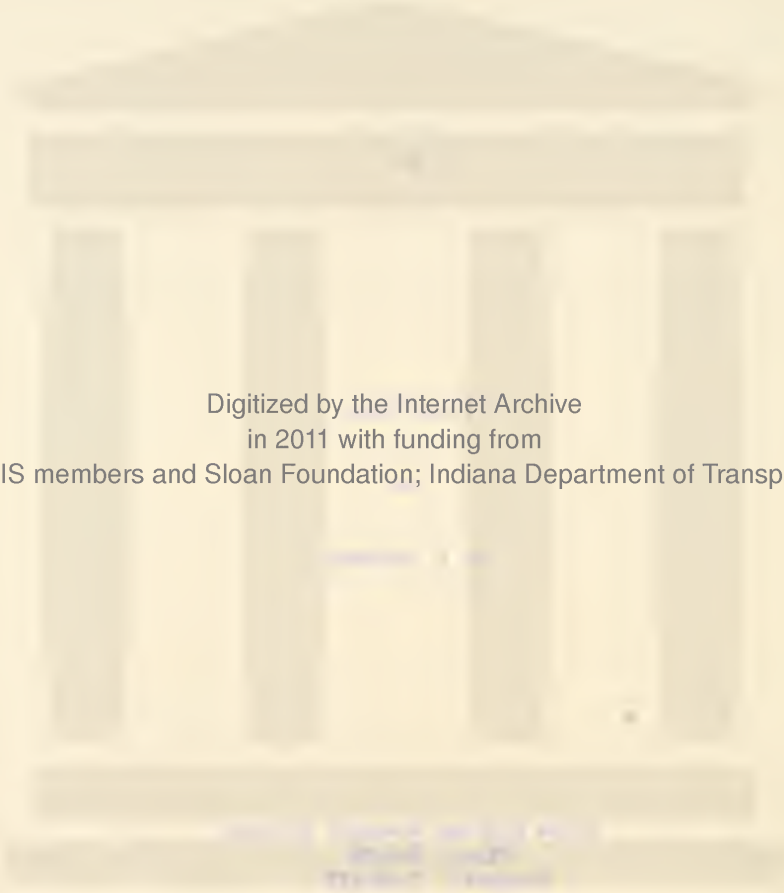

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USE AND DESIGN OF ACCELERATION AND DECELERATION LANES IN INDIANA

INTRODUCTION

On the basis of various and recent research studies, it is apparent that highway designers are becoming more and more concerned with the relationship between highway design and traffic behavior. An excellent example of current interest is the design of acceleration and deceleration lanes. In order to be able to obtain maximum efficiency and safety in the operation of acceleration and deceleration lanes, and to maintain efficiency on the main facility, it is necessary to relate the design of such lanes to traffic behavior as indicated by the requirements and desires of drivers.

Drivers leaving a highway at an intersection usually are required to reduce speed before turning. On the other hand, drivers entering a highway at an intersection have to accelerate in order to reach the desired speed of the traffic on the facility. Whenever this deceleration or acceleration by exiting or entering traffic takes place on the main traveled way of the highway, it disrupts the flow of through traffic and is hazardous (1)*. Thus, in order to minimize these undesirable aspects on high speed facilities, maximum use should be made of acceleration and deceleration lanes.

For best operating conditions, acceleration and deceleration lanes should be used for the entire acceleration and deceleration phase by vehicles entering or leaving the through traffic lane. Each such acceleration and deceleration lane, therefore, should be of a design which will enable a driver to maneuver his vehicle onto it without a major change in speed and, once on it, to make the necessary change between the speed of operation on

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* Numbers in parentheses refer to entries in the list of references.

the main facility and the lower speed required for exit or entrance. The optimum condition of operation for an acceleration lane is to have acceleration lane traffic accelerate on the acceleration lane and merge at approximately the same direction of travel and at the same speed into through lane traffic. That for a deceleration lane is to have deceleration lane traffic leave the through lane at about the same direction of travel as through lane traffic and at the same speed, with all deceleration taking place in the deceleration lane.

Acceleration and deceleration lane design varies very significantly from state to state. Some states follow the standards set forth in the manual, "A Policy on Geometric Design of Rural Highways" by the American Association of State Highway Officials (AASHO) (1). Other states have developed their own standards using the AASHO manual as a guide.

The Indiana State Highway Commission has used several designs for acceleration and deceleration lanes. The parallel lane type of acceleration lane was initially adopted as a standard. This design consisted of a full width lane 350 feet long plus 400 feet of taper and it has been constructed at several locations. Later the length of the parallel acceleration lane was changed to 250 feet of full width with 250 feet of taper. Later yet, the direct taper type of acceleration lane design was adopted in order to correct a tendency for entering traffic to move into the through lane too quickly. This latter acceleration lane has a 750 foot taper. More recently an acceleration lane having 50:1 taper was adopted. This design is similar to one described in "Traffic Behavior on Freeways," Highway Research Board Bulletin 235. This last design, however, had not been incorporated in any construction completed prior to 1962.

Adopted standards for the State of Indiana for deceleration lanes have also included the parallel lane type and the direct taper type. One design uses a taper from zero (0) to twelve (12) foot lane width in 250 feet, followed by 50 feet of tangent and then a curve. A second design utilizes a continuous curve. A third design has a taper followed by a curve, and a fourth design uses a straight short taper. During 1961 a design having about 900 foot of straight taper was adopted.

This paper reports the speed and lateral placement of vehicles on acceleration and deceleration lanes of various designs as constructed in Indiana. It also correlates acceleration and deceleration lane design with traffic behavior and apparent driver requirements and suggests acceleration lane and deceleration lane design or designs which appears to provide the most efficient and safe operation.

SCOPE

The study was limited to high type facilities in the State of Indiana. Locations were chosen on the Indiana Toll Road and those sections of the Interstate System that were completed and had been opened to traffic prior to 1962. The study locations were specifically selected to provide data on speeds and lateral placement for various designs of acceleration and deceleration lanes and for operations under different conditions. Not all of the different designs of acceleration and deceleration lanes which have been adopted by the Indiana State Highway Commission could be studied as some of these designs had not as yet been incorporated in any completed construction.

Locations were chosen, if possible, so as to include three conditions of road geometry, i.e., where the acceleration or deceleration lanes met or

left the through lanes on 1) a tangent, 2) a right curve, or 3) a left curve. One location was also studied where an acceleration lane joined the through lane on the upgrade portion of a crest vertical curve, and another was included where the junction occurred on the downgrade portion of a sag vertical curve. All these conditions were studied in order to evaluate the effects, if any, that each of these conditions have on traffic behavior and to determine which condition provides for the most efficient and safe use of acceleration and deceleration lanes.

In four cases, more than one location having the same acceleration or deceleration lane design and similar conditions of road geometry were studied. These studies were made at different locations having different traffic, in order to evaluate the repetitive character of the results. It was suspected that other factors such as traffic volumes and types of drivers using the facility would have a significant bearing upon the results.

The speeds of through vehicles were also analyzed at each interchange in the vicinity of where the acceleration or deceleration lanes joined the through lanes. This was done in order to compare speeds of acceleration or deceleration lane traffic with through lane traffic at each location. The speeds of through traffic were also obtained before or after the interchanges as pertinent, in order to evaluate if the interchange traffic had any effect on the speed of through traffic at the interchange.

The types of vehicles studied were passenger cars and light trucks, which were considered as passenger cars. Heavy trucks were not included as the percentage of such trucks using acceleration and deceleration lanes on existing Indiana freeways was small and a long and expensive period of data collection to obtain an adequate sample of trucks would have been required. Information on

the use by trucks of acceleration and deceleration lanes is certainly desirable and should be obtained. During the course of the study the location where deceleration lane traffic begins to decelerate while on the through lanes and before the beginning of the deceleration lane was found to be of interest. This information, therefore, was obtained for a few of the study locations for deceleration lanes. Only information for free-moving vehicles was utilized for all parts of this study.

Vehicles that stopped on the acceleration or deceleration lanes were not included in the speed and lateral placement evaluations but were recorded for possible use as a measure of the efficiency of operation of the various designs.

PROCEDURE

The data on speeds and lateral placement of traffic using acceleration and deceleration lanes were obtained by use of motion picture techniques using a 16mm motion picture camera. The motion picture type of study was selected, after consideration of various other methods, as being the best for detailed study and analysis.

The filming was done from a vantage point, usually an overpass over the main facility at the interchange. The camera used was a 16mm Bell and Howell movie camera with a built-in turret head.

In the case of acceleration lanes, movies were taken of each free-flowing passenger car as it passed a designated point, usually the nose, beyond which it was able to maneuver and merge onto the through lanes, and until the left rear wheel of the vehicle crossed from the acceleration lane onto the through lane. The left rear wheel of the car was chosen as the

criterion because acceleration lane traffic traveled away from the camera and therefore was visible, and for all practical purposes the instant the left rear wheel crosses from the acceleration lane onto the through lane conflict with the through traffic operation becomes serious.

As for the deceleration lane, movies were taken of each vehicle just as its left front wheel crossed from the through lane onto the deceleration lane and until it passed a designated point on the deceleration lane, usually the nose, beyond which the car was unable to maneuver back onto the through lane. Here the left front wheel of the car was chosen because for deceleration lanes, traffic traveled towards the camera and most of the car by that point had left the through lane and was no longer a conflict on the through lanes.

The film was analyzed by projecting it through a time-motion study projector. A grid was superimposed on the screen where the film was projected to a scale which provided accurate ground measurements. The vehicle speeds at various locations on the acceleration and deceleration lanes were computed using the grid system by determining the distance traveled during a time period. Time was measured by the number of frames a vehicle traveled between two grid lines. The lateral placement of the vehicles on the acceleration or deceleration lanes was also traced by using the grid system. The stations at which the left rear wheel of acceleration lane traffic and left front wheel of deceleration lane traffic crossed the line between the acceleration or deceleration lane and through lanes were noted.

Speed information was grouped by 100 foot stations according to the location on the acceleration or deceleration lane where each car merged or diverged. For example, the speed data for all vehicles on a study lane which merged between Station 0+00 and Station 1+00 were grouped for analysis. The average speed, 85th percentile speed, standard deviation and percent of

total vehicles leaving or entering between stations were computed for each group. The 85th percentile speed and percent leaving or entering between 100 foot stations are indicated on the sketches of each study site which are included in this report. A single value for the 85th percentile speed for all vehicles entering or leaving the deceleration or acceleration lane is shown on these same sketches in parenthesis.

A cumulative frequency graph of lateral placements was plotted for each study site. This graph was developed by plotting the cumulative percent of vehicles which merged or diverged into or from the through lane against the distance from the nose at which the merger or divergence occurred. It was found that the cumulative curves thus prepared tended to break sharply at approximately 90 percent. Thus the 90th percentile was taken as an important criterion for determining the length of an acceleration or deceleration lane which would be effectively used.

Spot speeds of through lane traffic were measured using the radar meter. The spot speeds of through traffic were measured at two locations at each study site. The first of these was "within the area of conflict", the area where acceleration or deceleration lanes adjoined the through lane. The second spot speed location was "beyond the area of conflict", a point approximately a mile before or after the interchange.

Spot speeds of deceleration lane traffic were measured at three deceleration lane sites in an attempt to determine where traffic destined for a deceleration lane begins to decelerate on the through lane. The radar meter was placed so that the cars approaching the deceleration lane intersected the beam at the specified location, but only cars that proceeded to use the deceleration lane were recorded.

LOCATIONS AND RESULTS

Acceleration Lanes

Figure 1 is a map of the State of Indiana showing the location of the acceleration and deceleration lanes studied. Pertinent data for each acceleration lane location are given in Table 1. These locations are coded as follows: A1a, A2b, etc. where the "A" stands for acceleration lane; the 1, 2, etc. for the type of acceleration lane design; and a, b, etc. for the location.

Acceleration Lanes, Type 1

One type of acceleration lane studied is on the Indiana Toll Road and is of the design shown in Figure 2. The length of the acceleration lane is 1200 ft. from the end of the ramp curve to the intersection with the right edge of the through lane. A shoulder, which is paved but of different color, separates the acceleration lane from the through lane for a distance of 577.82 ft. For some of this distance, a curb also adjoins the acceleration lane. Beyond the point of separation, the acceleration lane is an extra lane with a 52:1 straight taper from a width of twelve (12) ft. to zero (0) ft. in a distance of 622.03 ft.

Six locations of this type of acceleration lanes were studied. At two of these locations the acceleration lane meets the through lane on a tangent, at a third on a tangent and also on the downgrade portion of a sag vertical curve, at a fourth location on a right curve, at a fifth on a right curve and also on the upgrade portion of a crest vertical curve and at a sixth on a left curve.

Station 0+00 was placed as the end of the ramp curb; beyond this point acceleration lane traffic could merge into the through lanes.

Figures 3, 4, 5, 6, 7, and 8 show the results of the speed and lateral placement studies made at these locations. The results at location A1a are discussed in the following paragraphs as an illustrative example of how each of these figures and the data in Table 3 were analyzed. A summary of the important characteristics of use obtained at each location are given in Table 3.

Location A1a

The acceleration lane meets the through lane on a tangent at the interchange. The annual average daily traffic (1960) on the acceleration lane was 620 vehicles per day and on the west bound through lanes was 3720 vehicles per day.

Figure 3 shows the results of the speed and lateral placement study made at this location. On this figure, as on similar figures for other locations of acceleration and deceleration lanes studied, 85th percentile speeds are shown for acceleration lane traffic and for through lane traffic. For acceleration lane traffic, the 85th percentile speed is given for Station 0+00 and for all vehicles which left the acceleration lane in each 100 feet thereafter at the time of merging. The percentage of the total non-stopping vehicles using the acceleration lanes which left the lane in each 100 feet and the cumulative percentage leaving at the end of each 100 feet are also given. The average 85th percentile speed of all vehicles using the acceleration lanes and at the time of their merging, except those which stopped, is shown by a number in parentheses, (55) in Figure 3. The 85th percentile speed for through lane traffic is given for a point within the area of merging and at a point approximately one (1) mile from this area. All percentages of acceleration lane traffic used in this report are on the basis of the total passenger cars and light trucks using the lane which did not stop before entering the through lane.

The 85th percentile speed of acceleration lane traffic for location A1a at Station 0+00 was 48 mph (see Figure 3). The difference between the 85th percentile speed of through traffic within the area of conflict and the average 85th percentile speed of acceleration lane traffic as it merged into the through lane was 14 mph (69-55). This difference is statistically significant and indicates that much of the acceleration lane traffic did not accelerate to about the same speed as the through lane traffic before merging with it.

The difference between the 85th percentile speed of through lane traffic within the area of conflict and that beyond the area of conflict was zero (0) (69-69).

Ninety percent of the traffic using the acceleration lane merged into the through lane prior to Station 4+50. This indicates that the majority of drivers merged within a distance of about 185 feet (4+50 - 2+65) beyond the point of separation of the acceleration lane from the through lane by means of the paved shoulder.

For this 52:1 taper design and at this location the natural straight path of the left wheels of acceleration lane vehicles intersects the edge of the through lanes between Stations 4+00 and 5+00. Only 18.5 percent of acceleration lane traffic, however, merged in this area. The majority, 79.6 percent, merged between Stations 3+00 and 4+00. It thus merged earlier than the natural straight path and at significantly lower speeds than through lane traffic.

A small percentage, 1.9 percent, merged into the through lanes between Stations 5+00 and 6+00 at an 85th percentile speed of 51 mph. This small percentage of vehicles made use of a longer distance of the acceleration lane and yet they merged at lower speeds than those at the previous indicated

locations. The reasons for this are either that these cars had to slow down due to conflicts with through traffic or that the drivers hesitated before merging due to inexperience in driving on high type facilities or not understanding the proper usage of acceleration lanes.

Of all vehicles using this acceleration lane, one (1) percent stopped on the acceleration lane.

These results indicate that at this location, this type of acceleration lane design is not being properly used by the majority of drivers.

Acceleration Lanes, Type 2

The second type of acceleration lane studied is shown in Figure 9. The acceleration lane is of the parallel type having a full width lane for 350 feet and 400 feet of taper. Five locations of this type of acceleration lane were studied. At three of the locations of acceleration lane meets the through lane on a tangent, at the fourth location on a right curve, and at the fifth location on a left curve. Station 0+00 for this type of lane was taken to be at the nose. Beyond this point acceleration lane traffic could merge into the through lane.

The results of the speed and lateral placement studies of these five locations are shown in Figures 10, 11, 12, 13, and 14.

Acceleration Lanes, Type 3

The third type of acceleration lane studied is illustrated in Figure 15. The acceleration lane is of the parallel type having a full width lane of 250 feet plus 250 feet of taper.

Two locations of this type of acceleration lane were studied. At the first location the acceleration lane meets the through lane on a tangent and at the second on a left curve. No suitable location could be found where the acceleration lane met the through lane on a right curve.

Figures 16 and 17 show the results of the speed and lateral placement studies at these two locations.

Acceleration Lanes, Type 4

The fourth type of acceleration lane studied is shown in Figure 18. This acceleration lane is of the taper design, but has only 300 feet of taper.

Two locations were studied of this type of acceleration lane and both locations were at the same interchange. At the first location the acceleration lane meets the through lane on a tangent and at the second on a right curve. No suitable location could be found where the acceleration lane met the through lane on a left curve.

Figures 19 and 20 show the results of the speed and lateral placement studies at these two locations.

Deceleration Lanes

The locations of the deceleration lanes studied are also shown in Figure 1 on a map of the state of Indiana and pertinent data for each location is given in Table 2. These locations are referenced as follows: D1a, D2b, etc. where the "D"stands for deceleration lanes; the 1, 2, etc. for the type of deceleration lane design; and the a, b, etc. for the location.

Deceleration Lanes, Type 1

The first type of deceleration lane studied was on the Indiana Toll Road and is as shown in Figure 21. The deceleration lane is 1200 feet long from the right edge of the through lane to the beginning of the ramp curve. It consists of 845 feet of direct taper, having an angle of divergence of one (1) degree and thirty (30)minutes with the through lanes. Along this distance the deceleration lane is not separated from the through lane. It is then connected to a 356 foot direct taper, having an angle of divergence of four (4) degrees with the through lane. For this 356 feet the deceleration

lane is separated from the through lanes by a shoulder which is paved but of a different color than the traveled area. The exit nose is offset six (6) feet from the edge of the through lane and there are 173 feet of recovery.

Three locations were studied of this type of deceleration lane. At two of the locations the deceleration lane leaves the through lanes on a tangent and at the third on a left curve. No suitable location could be found where the deceleration lane left the through lane on a right curve.

Station 0+00 was taken at the nose which is the point where the paved shoulder which separates the deceleration lane and the through lane begins. At the end of the deceleration lane and the beginning of the exit ramp there is an advisory speed sign "Ramp Speed 25".

Figures 22, 23, and 24 show the results of the speed and lateral placement studies at these three locations. The results at location D1c are described herewith as an illustrative example of how the information shown on the figures was analyzed. Also a summary of the important deceleration lane characteristics and a summary of the results obtained at each location studied are given in Table 4.

Location D1c

The deceleration lane leaves the through lane at this location on a left curve. The annual average daily traffic on the deceleration lane was 730 vehicles per day and on the through lanes east bound was 6630 vehicles per day.

The difference between the 85th percentile speed of through lane traffic within the area of conflict and the average 85th percentile speed of deceleration lane traffic as it diverged into the deceleration lane was 14 mph (69-55) (see Figure 24). This difference is significant and indicates that

most of this deceleration lane traffic started to decelerate on the through lane before diverging into the deceleration lane.

Because of the significant deceleration on the through lane at this location, a study was made as to where it occurred with respect to the beginning of the deceleration lane. Figure 25 shows for 200 foot intervals prior to the beginning of the deceleration lane the 85th percentile speeds for the traffic which later entered the deceleration lane. Through traffic in this area was traveling at 69 mph. There is a clear indication that some of the traffic planning to use the deceleration lane at this location begins to decelerate well in advance (over 1000 feet) of the deceleration lane.

The data given in Figure 22, as well as that in similar figures for other deceleration lanes, are similar to that given for acceleration lanes, and explained in an earlier section of this report.

Approximately 90 percent of the drivers using the deceleration lane diverged within a distance of approximately 400 feet.

The natural straight path of exit of the left wheels of the vehicles, which was taken as a line parallel to but offset by a distance of three (3) feet from that path joining the point of beginning of the deceleration lane with the end point of the deceleration lane at the nose (Station 0+00), intersects the through lane between Station 4+00 and 5+00, where only a small percentage, 8.3 percent, of deceleration lane traffic diverged at an 85th percentile speed of 68 mph. Most of the remaining drivers diverged later and at lower speeds thus indicating deceleration on the through lane instead of on the deceleration lane. This could have been aggravated by the effect of the left curve.

A small percentage, 3.7 percent, of deceleration lane traffic crossed the paved shoulder and diverged between Stations 0+00 and 1+00 at an 85th

percentile speed of 46 mph. This speed is lower than that of other observed deceleration lane traffic, and this might have been caused by these drivers hesitating on the through lane and making the decision at the last minute to leave at this interchange.

These results indicate for this roadway geometry and this type of deceleration lane design, that drivers were not properly using the deceleration lane at this location.

Deceleration Lanes, Type 2

The second type of deceleration lane studied is shown in Figure 26. The deceleration lane has a taper from zero (0) feet to twelve (12) feet in a distance of 250 feet, followed by 50 feet of tangent and 195 feet of curve. Near the exit nose there is a regulatory speed sign "Exit Speed 40". Three locations of this type of deceleration lane were studied. At two of the locations the deceleration lane leaves the through lane on a tangent and at the third on a right horizontal curve. No suitable location could be found where the deceleration lane left the through lane on a left curve. Station 0+00 was taken at the nose of the deceleration lane.

The results of the speed and lateral placement studies at these locations are shown in Figures 27, 28, and 29.

Deceleration Lanes, Type 3

The third type of deceleration lane studied is shown in Figure 30. The deceleration lane in this design is a cruve of varying degrees of curvature. Near the nose there is a regulatory speed sign "Exit Speed 40".

Three locations were studied of this type of deceleration lane. At the first location, the deceleration lane leaves the through lane on a tangent, at the second on a right curve and at the third on a left curve.

The results of the speed and lateral placement studies at these three locations are shown in Figures 31, 32, and 33. Figures 34 and 35 show the results of a study at two of these locations where the distance prior to the beginning of the deceleration lane and in which the deceleration occurred was determined.

Deceleration Lanes, Type 4

The fourth type of deceleration lane studied is shown in Figure 36. The deceleration lane in this design is a direct taper 400 feet long. Near the exit nose there is a regulatory speed sign, "Exit Speed 40".

Only one location was studied of this type of deceleration lane as it was the only one completed as of the date of this study. Figure 37 shows the results of the speed and lateral placement study at this location.

Deceleration Lanes, Type 5

The fifth type of deceleration lane studied is shown in Figure 38. The deceleration lane in this design is a variable distance direct taper followed by a curve. Near the exit nose there is a regulatory speed sign "Exit Speed 40".

Three locations were studied of this type of deceleration lane. At the first two locations the deceleration lanes leave the through lanes on a tangent and at the third on a left curve. At the first and third location the length of the tangent section is 200 feet and the length of the curve portion to the nose is 139 feet while at the second location these lengths are 250 feet and 217 feet, respectively.

Figures 39, 40, and 41 show the results of the speed and lateral placement studies at these three locations.

Summary of Field Results

A summary of the important acceleration lane characteristics and a summary of the results obtained at each location studied are given in Table 3. A similar table for the deceleration lanes studied is Table 4. These two tables provide a comparison of the use characteristics found on the various designs and permit a rather rapid comparison of the various designs and resulted in the findings which are given in the next section of this report.

FINDINGS AND RECOMMENDATIONS

The behavior of vehicles on acceleration and deceleration lanes as found and reported in the numerous figures and the summary tables in this report indicates the following:

In General:

1. There are large differences in speed between acceleration or deceleration lane traffic at the time of merging or diverging, respectively, and that of the through lanes on the Interstate Sections studied. It is obvious that better use of these and similar faciliities which will be constructed is desirable.
2. A large number of motorists apparently do not know how to properly use acceleration and deceleration lanes. Thus, for the most efficient and safest operation of traffic, it is imperative that the driving public be better informed on the proper use of acceleration and deceleration lanes. It is recommended that all the interested agencies of the City, State and Federal Government recognize their responsibility in this area and formulate at an early date a program of education directed toward the proper use of acceleration and deceleration lanes.

To facilitate this education of the driving public in the use of such lanes and to eliminate much of the confusion which motorists now exhibit, one standard design for acceleration lanes and one for deceleration lanes should be adopted for the Interstate System. The Indiana State Highway Commission has already constructed three different designs of acceleration lanes and four different designs of deceleration lanes on the Interstate Sections that have been opened to traffic. On some of these sections the design varies from one interchange to the next.

3. The use results are not similar at all locations for acceleration and deceleration lanes having the same design and operating under the same roadway geometry. This indicates that other factors, such as types of driver using the lanes and traffic volume, have a significant bearing upon the results.

4. Acceleration or deceleration lane traffic has little effect upon the speed of through traffic at interchanges where acceleration and deceleration lanes of the designs studied in this project are provided and where the acceleration or deceleration lanes and ramps have adequate capacity.

At only eight (8) of the 28 acceleration and deceleration lane locations studied was the difference in the 85th percentile speed of the through lane traffic within the area of conflict and that beyond the area of conflict statistically significant. Drivers slowed at seven (7) of these locations and traveled faster at the eighth. The change in speed was never greater than six (6) mph.

At some of the locations where the speed effect was significant, other factors, such as a narrow median or a horizontal curve, probably contributed to the changes in speed.

5. For the best use for both acceleration and deceleration lanes at an interchange location, it is desirable to have the through lanes, at the location of the acceleration or deceleration lanes, on a tangent and as near a level grade as possible.

For Acceleration Lanes:

1. A higher percentage of drivers utilize more length of the acceleration lane when the acceleration lane meets the through lane on a right curve, and less length of the acceleration lane when it meets the through lane on a left curve, than the condition where the acceleration lane meets the through lane on a tangent.
2. Of the four acceleration lane designs studied, the long direct taper type of design with separation from the through lanes for approximately 500 feet was found to be the only type where most drivers tended to approach the optimum condition of operation for acceleration lanes.
3. For the long direct taper design, a high percentage of drivers followed a natural straight path from the beginning of the acceleration lane at the end of the ramp curve until they merged into the through lanes. Some control, such as a curb, appeared to be desirable beyond the end of the ramp curve to properly align some motorists in a straight path that most of them used on this type of acceleration lane and thus prevent a too early merging at too too low a speed into the through lane.

4. For the long direct taper type of design studied, most drivers merged (left rear wheel entered through lane) within a maximum distance of 260 feet beyond the nose.
5. Most drivers tended to merge soon after entering all parallel acceleration lanes studied and at too low a speed. A longer length of the parallel portion of the acceleration lane did not show better usage than a shorter length.
6. Most drivers tended to merge as soon as possible and at too low a speed on the short taper design acceleration lanes which had no separation from the through lanes.

For Deceleration Lanes:

1. A higher percentage of drivers utilized less length of the deceleration lane and diverged later at lower speeds, thereby decelerating more on the through lane, when the deceleration lane left the through lane on a left curve than when the deceleration lane left the through lane on a right curve or tangent.
2. Most drivers at most of the locations studied did not obey the regulatory speed signs "Exit Speed 40" placed near the nose of the deceleration lane on the Interstate sections. It is suggested that this regulatory speed sign be changed to an advisory ramp speed sign with the numerical value the safe design speed of the exit ramp and placed so as to permit comfortable deceleration to this safe speed.
3. At all but one of the locations studied, much of the deceleration lane traffic started to decelerate on the through lane before

diverging into the deceleration lane. The results further show that many drivers began to decelerate well in advance, more than 1000 feet, of the beginning of the deceleration lane.

4. Of the five types of design studied, the long direct taper type of deceleration lane with separation of the lane from the through lane for about 300 feet (as on the Indiana Toll Road) was found to be the best. On this design most drivers tended to approach the optimum condition of operation for deceleration lanes. On the lanes of this design studied, it appears that a shorter diverging distance and a longer separated deceleration lane would be desirable.

5. Most drivers on the deceleration lanes studied desired to follow a natural straight path of exit with a minimum of maneuvering. Thus only a small percentage of drivers properly used the parallel type of design. This type of design requires drivers to make an additional maneuver and to follow the pattern of a reverse curve - a movement which apparently appears to be unnecessary to most drivers.

6. Ninety percent of the drivers diverging onto a deceleration lane did so within a maximum distance of 300 feet except for one case where the lane was on a left horizontal curve.

7. The curve type design for deceleration lanes tended to provide good usage throughout the length of the lane but most drivers decelerated considerably before entering lanes of this design. This latter tendency may be corrected through the use of a long and very slight curve.

8. Most drivers tended to decelerate appreciably on the through lane where a short direct taper design was used.

PROPOSED STANDARD DESIGNS FOR ACCELERATION AND DECELERATION LANES

The characteristics of use found in this study indicate that a good design for acceleration and deceleration lanes should provide:

1. Adequate length for acceleration lane traffic to accelerate comfortably from the safe ramp speed to the through lane traffic speed.
2. Adequate length for deceleration lane traffic to decelerate from the through lane traffic speed to the safe ramp speed.
3. Adequate merging or diverging distance to handle safety low volumes as well as high volumes (to practical capacity) of traffic on both the through lanes and the acceleration or deceleration lanes.
4. Adequate sight distance to allow drivers to maneuver safely through the interchange area.
5. Adequate signage and delineation at the interchange area to eliminate any confusion in differentiating between the acceleration or deceleration lanes and the through lanes and in properly maneuvering through the interchange.
6. A small angle, one to three degrees if possible, of convergence (acceleration lanes) and a small angle of divergence (deceleration lanes) so that the maneuver can be made in approximately the same direction of travel as that being performed by through traffic.
7. Separation of the acceleration lane or deceleration lane from the through lane for an adequate portion of the length of the acceleration or deceleration lane. At the beginning of an acceleration lane a curb may be necessary to align properly drivers coming from the ramp curve.

The above characteristics and findings of this study were used to prepare the proposed standard acceleration lane and proposed standard deceleration lane shown in Figures 42 and 45, respectively.

Proposed Acceleration Lane Design

This proposed design handles two fundamental vehicular maneuvers, acceleration followed by merging.

The accelerating distance is that length of the acceleration lane from the end of the ramp curve to the nose. This length permits acceleration lane traffic to accelerate from the safe ramp speed, assumed for Figure 42 to be 25 mph, to the design speed of the facility, assumed to be 70 mph.

From Figures 43 and 44 which were prepared from data given by Stonex (13) the distance required to accelerate from one speed to another was determined for the best and poorest performing cars for three model years. These distances for 25 mph to 70 mph are tabulated below and show that the acceleration distance required for the poorest performing car considered is 612 feet.

DISTANCES REQUIRED FOR VARIOUS MODEL CARS TO ACCELERATE FROM 25 MPH TO 70 MPH

Year of Model	Poorest Performing Cars	Best Performing Cars
1951	612	312
1955	560	250
1959	475	257

A distance of 625 feet was therefore used for the proposed example design.

The merging distance is that length of the acceleration lane from the nose to the end of the acceleration lane. This length enables acceleration lane traffic to merge from the acceleration lane to the through lane while traveling at the design speed of the facility, 70 mph in the example. This

study indicated that the majority of drivers merged on the long taper type acceleration lane within a maximum distance of about 260 feet. This distance was for the left rear wheel and means the total vehicle would be easily in the through lane within 500 feet. This distance was adequate for the volume of traffic using the main facility and the acceleration lane at the time of the study, but acceleration lanes should be designed so that the facility can accommodate practical capacity. However, recent capacity studies (8) (11) (14) have shown that maximum flow can only be obtained where the "squeeze off" distance is about 500 feet, and that longer merging area do not handle larger merging volumes. A distance of 500 feet, therefore, was assumed for this design.

The length of the acceleration lane for an increase in speed from 25 to 70 mph is 1125 feet from the end of the ramp curve to the intersection with the right edge of the through lane. It has about 45:1 direct taper all along its merging distance. A curb adjoins the acceleration lane for the first 425 feet and for the next 200 feet a shoulder, which is paved but of different color, separates the acceleration lane from the through lane. The acceleration lane shown has a very small angle of convergence, about one (1) degree.

Proposed Deceleration Lane Design

The proposed deceleration lane is designed to accommodate two fundamental maneuvers, diverging and then deceleration.

The diverging distance is that length of the deceleration lane from the beginning of the lane to the nose. This length enables deceleration lane traffic to diverge from the through lane onto the deceleration lane while still traveling at the design speed of the facility, also assumed for Figure 45 to be 70 mph. This study indicated that most drivers diverged within a maximum

distance of 300 feet. Allowing for a factor of safety the diverging length proposed is 500 feet.

The deceleration distance is that length of the deceleration lane from the nose to the beginning of the ramp curve. This length enables deceleration lane traffic to decelerate from the design speed of the facility to the safe speed of the exit ramp.

Various studies (2, 3, 15) have recommended comfortable deceleration rates ranging from 6.2 mph per second to 9.4 mph per second. A uniform deceleration rate of 6.2 mph per second was used for the design shown in Figure 45.

Thus time (t) required to decelerate from the 70 mph to 25 mph used for Figure 45 equals 7.26 seconds during which time the motorist will travel about 500 feet.

The deceleration lane in Figure 45 therefore is 1000 feet long, from the edge of the right lane to the beginning of the ramp curve. It has a small angle of divergence, about two (2) degrees, at the through lane.

The exit nose is offset six (6) feet and there are 175 feet of recovery. Two advisory speed signs are posted indicating to the drivers the design speed of the exit ramp. One is located at the nose to give the driver advance warning and to enable him to decelerate within the deceleration distance, and the other located at the beginning of the exit ramp.

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TABLE 1

PERTINENT DATA FOR STUDY LOCATIONS - ACCELERATION LANES

Accel. Lane Identification	Location	Direction of Accel. Lane Traffic	Geometric Conditions		Type of Accel Lane	
A1a	Indiana Toll Road - Middlebury	West Bound	Tangent	(1)*	Direct Taper 1200'	1
A1b	Gary West	West Bound	Tangent	(1)	Direct Taper 1200'	1
A1c	Michigan City	West Bound	Tangent and Downgrade Portion of Sag Vertical Curve	(4)	Direct Taper 1200'	1
A1d	Chesterton-Valparaiso	West Bound	Right Curve	(2)	Direct Taper 1200'	1
A1e	LaPorte	West Bound	Right Curve and Upgrade Portion of Crest Vertical Curve	(5)	Direct Taper 1200'	1
A1f	Gary East	East Bound	Left Curve	(3)	Direct Taper 1200'	1
A2a	Interstate 65 - State Road 39	North Bound	Tangent	(1)	Parallel-350' Str and 400' taper	2
A2b	Tri State - Kennedy Ave.	East Bound	Tangent	(1)	Parallel-350' Str and 400' Taper	2

* Numbers in parentheses (1) identify the geometric conditions used in this report by number
**Numbers 1, 2, etc. refer to the type of acceleration lane used in this report identified by number

Table 1 (Continued)

Accel. Lane Identification	Location	Direction of Accel. Lane Traffic	Geometric Condition		Type of Accel. Lane	
A2c	Interstate 74 - Post Road	East Bound	Tangent	(1)	Parallel-350' Str and 400' Taper	2
A2d	Interstate 65 State Road 60	South Bound	Right Curve	(2)	Parallel-350' Str and 400' Taper	2
A2e	State Road 39	South Bound	Left Curve	(3)	Parallel-350' Str and 400' Taper	2
A3a	State Road 56	North Bound	Tangent	(1)	Parallel-250' Str and 250' Taper	3
A3b	State Road 334	North Bound	Left Curve	(3)	Parallel-250' Str and 250' Taper	3
A4a	Tri-State - Calumet Ave.	East Bound	Tangent	(1)	Direct Taper 300'	4
A4b	Calumet Ave.	West Bound	Right Curve	(2)	Direct Taper 300'	4

TABLE 2

PERTINENT DATA FOR STUDY LOCATIONS - DECELERATION LANES

Reference	Location	Direction of Deceleration Lane Traffic	Geometric Condition		Type of Decel. Lane	
D1a	Indiana Toll Road-Gary West	East Bound	Tangent	(1)*	Direct Taper 1200'	1**
D1b	Michigan City	West Bound	Tangent	(1)	Direct Taper 1200'	1
D1c	Chesterton-Valparaiso	East Bound	Left Curve	(3)	Direct Taper 1200'	1
D2a	Interstate 65 and State Road 39	South Bound	Tangent	(1)	250 ft Taper and 50 ft Straight + curve	2
D2b	Tri-State and Kennedy Avenue	West Bound	Tangent	(1)	250 ft Taper and 50 ft Straight + curve	2
D2c	Interstate 65 and State Road 39	North Bound	Right Curve	(2)	250 ft Taper and 50 ft Straight + curve	2
D3a	Interstate 74 and State Road 9	East Bound	Tangent	(1)	Curve	3
D3b	Interstate 65 and State Road 334	South Bound	Right Curve	(2)	Curve	3

* Numbers in parentheses (1) identify the geometric conditions used in this report by number
**Numbers 1, 2, etc. refer to the type of deceleration lane used in this report identified by number

TABLE 2 (continued)

Reference	Location	Direction of Deceleration Lane Traffic	Geometric Condition		Type of Decel. Lane	
D3c	Interstate 65 and State Road 60	North Bound	Left Curve	(3)	Curve	3
D4a	Interstate 74 and Pleasant View	East Bound	Tangent	(1)	Direct Taper - 400 ft	4
D5a	Tri-State and Calumet Avenue	West Bound	Tangent	(1)	Taper - 200ft ≠ curves	5
D5b	Interstate 65 and State Road 56	North Bound	Tangent	(1)	Taper - 250ft ≠ curves	5
D5c	Tri-State and Calumet Avenue	East Bound	Left Curve	(3)	Taper - 200ft ≠ curves	5

Location	Figure No.	Geometric Condition No.	Length of Accel. Lane Unused by 90% of Through Lane Traffic	% of Accel. Lane Traffic That Stopped	Was This Accel. Lane Used Satisfactorily As To	
					Speed	Placement
A1a	3	(1)	125	1.0	No	No
A1b	4	(1)	110	10.7	Yes	Yes
A1c	5	(4)	110	1.8	No	Yes
A1d	6	(2)	60	3.6	Yes	Yes
A1e	7	(5)	110	3.7	No	Yes
A1f	8	(3)	120	0	Yes	Yes
A2a	10	(1)	200	9.3	No	No
A2b	11	(1)	150	16.0	No	No
A2c	12	(1)	265	4.4	No	No
A2d	13	(2)	50	14.3	No	No
A2e	14	(3)	235	10.7	No	No
A3a	16	(1)	100	14.3	No	No
A3b	17	(3)	110	3.6	No	No
A4a	19	(1)	115	34.6	No	No
A4b	20	(2)	120	28.0	No	No

1. Numbers in paren nificant
2. Numbers refer to as that length from the end of the ramp
3. AADT = Annual Av s 6 feet wide.
4. WAOC = Within Ar

TABLE 3

SUMMARY OF RESULTS - ACCELERATION LANES

Location	Figure No.	Geometric[1] Condition No.	Type of[2] Accel. Lane - No.	AADT[3]		85th Percentile Speed						Distance Beyond Point of Separation Within Which 90% of Accel. Lane Traffic Merged	Usable[7] Length of Accel. Lane	Length of Accel. Lane Unused by 90% of Through Lane Traffic	% of Accel. Lane Traffic That Stopped	Was This Accel. Lane Used Satisfactorily As To	
				Accel. Lane	Through Lane	Station 0 00	Average Accel. Lane	Through Lane WAOC[4]	Speed Diff. and (S) or (NS)[5]	Through Lane BAOC[6]	Speed Diff. and (S) or (NS)					Speed	Placement
A1a	3	(1)	1	620	3720	48	55	69	14 (S)	69	0 (NS)	185	890	125	1.0	No	No
A1b	4	(1)	1	1310	7860	54	62	65	3 (NS)	65	0 (NS)	200	890	110	10.7	Yes	Yes
A1c	5	(4)	1	870	5950	54	57	67	10 (S)	67	0 (NS)	200	890	110	1.8	No	Yes
A1d	6	(2)	1	650	6420	57	64	67	3 (NS)	69	2 (NS)	260	890	60	3.6	Yes	Yes
A1e	7	(5)	1	1230	5030	48	54	66	12 (S)	66	0 (NS)	200	890	110	3.7	No	Yes
A1f	8	(3)	1	590	6520	58	63	64	1 (NS)	69	5 (S)	190	890	120	0	Yes	Yes
A2a	10	(1)	2	260	4550	42	47	66	19 (S)	68	2 (NS)	450	650	200	9.3	No	No
A2b	11	(1)	2	680	17200	47	51	62	11 (S)	62	0 (NS)	500	650	150	16.0	No	No
A2c	12	(1)	2	1130	3030	55	55	61	6 (S)	63	2 (NS)	385	650	265	4.4	No	No
A2d	13	(2)	2	880	4530	42	50	64	14 (S)	58	-6 (S)	600	650	50	14.3	No	No
A2e	14	(3)	2	1380	4170	44	46	66	20 (S)	67	1 (NS)	415	650	235	10.7	No	No
A3a	16	(1)	3	670	2800	51	54	61	7 (S)	65	4 (S)	375	475	100	14.3	No	No
A3b	17	(3)	3	1450	2650	50	53	64	11 (S)	63	1 (NS)	365	475	110	3.6	No	No
A4a	19	(1)	4	1960	23730	44	48	60	12 (S)	66	6 (S)	135	250	115	34.6	No	No
A4b	20	(2)	4	3880	21620	41	45	60	15 (S)	60	0 (NS)	130	250	120	28.0	No	No

1. Numbers in parenthesis (1) refers to the condition referenced in Table 3
2. Numbers refer to types referenced in Table 3
3. AADT = Annual Average Daily Traffic.
4. WAOC = Within Area of Conflict
5. (S) = Significant (NS) = Not Significant
6. BAOC = Beyond Area of Conflict
7. Usable length of Accel. Lane is taken as that length from the end of the ramp curve to where the Accel. Lane width is 6 feet wide.

Location	Figure No.	Geo Con	7 h el. s	Length of Decel. Lane Not Used by 90% of Traffic	Was This Decel. Lane Used Satisfactorily As To	
					Speed	Placement
D1a	22		0	50	Yes	Yes
D1b	23		0	30	No	Yes
D1c	24		0	230	No	No
D2a	27		0	120	No	No
D2b	28		0	75	No	No
D2c	29		0	90	No	No
D3a	31		0	0	No	Yes
D3b	32		0	0	No	Yes
D3c	33		0	25	No	Yes
D4a	37		8	20	No	Yes
D5a	39		0	40	No	Yes
D5b	40		0	50	No	Yes
D5c	41		0	50	No	Yes

1. Numbers in pa t Significant
2. Numbers refer is taken as that length from
3. AADT = Annual where the Deceleration Lane
4. WAOC = Within

TABLE 4

SUMMARY OF RESULTS - DECELERATION LANES

Location	Figure No.	Geometric[1] Condition No.	Type of[2] Decel. Lane No.	AADT[3]		85th Percentile Speed						Distance Within Which 90% of Decel. Lane Traffic Diverged In.	Usable[7] Length of Decel. Lane	Length of Decel. Lane Not Used by 90% of Traffic	Was Thie Decel. Lane Used Satisfactorily As To	
				Decel. Lane	Through Lane	Station 0 00	Average Decel. Lane	Through Lane WAOC[4]	Speed Diff. and (S) or (NS)[5]	Through Lane BAOC[6]	Speed Diff. and (S) or (NS)				Speed	Placement
D1a	22	(1)	1	1460	7680	70	70	63	-7 (S)	69	6 (S)	300 ft	990	50	Yes	Yes
D1b	23	(1)	1	310	5910	52	60	64	4 (S)	68	4 (S)	300	990	30	No	Yes
D1c	24	(3)	1	720	6630	46	55	69	14 (S)	69	0 (NS)	400	990	230	No	No
D2a	27	(1)	2	240	4170	49	49	67	18 (S)	68	1 (NS)	200	370	120	No	No
D2b	28	(1)	2	1430	16790	41	46	60	14 (S)	63	3 (S)	200	370	75	No	No
D2c	-	(2)	2	1060	4550	46	50	68	18 (S)	70	2 (NS)	200	370	90	No	No
D3a	31	(1)	3	--	--	46	51	62	11 (S)	65	3 (S)	100	150	0	No	Yes
D3b	32	(2)	3	1010	3230	50	54	65	11 (S)	67	2 (NS)	100	150	0	No	Yes
D3c	33	(3)	3	930	4740	54	55	60	5 (S)	60	0 (NS)	200	300	25	No	Yes
D4a	37	(1)	4	250	3780	50	57	63	6 (S)	63	0(NS)	200	308	20	No	Yes
D5a	39	(1)	5	4100	21820	32	46	63	17 (S)	62	1 (NS)	100	240	40	No	Yes
D5b	40	(1)	5	770	2800	51	56	64	8 (S)	67	3 (NS)	100	340	50	No	Yes
D5c	41	(3)	5	1830	23530	35	42	61	19 (S)	60	1 (NS)	100	240	50	No	Yes

1. Numbers in parenthesis (1) refer to the geometric condition referenced in Table 2
2. Numbers refer to types referenced in Table 2
3. AADT = Annual Average Daily Traffic
4. WAOC = Within Area of Conflict
5. (S) = Significant and (NS) = Not Significant
6. BAOC = Beyond Area of Conflict
7. Usable length of Deceleration Lane is taken as that length from the beginning of the ramp curve to where the Deceleration Lane width is 6 feet wide.

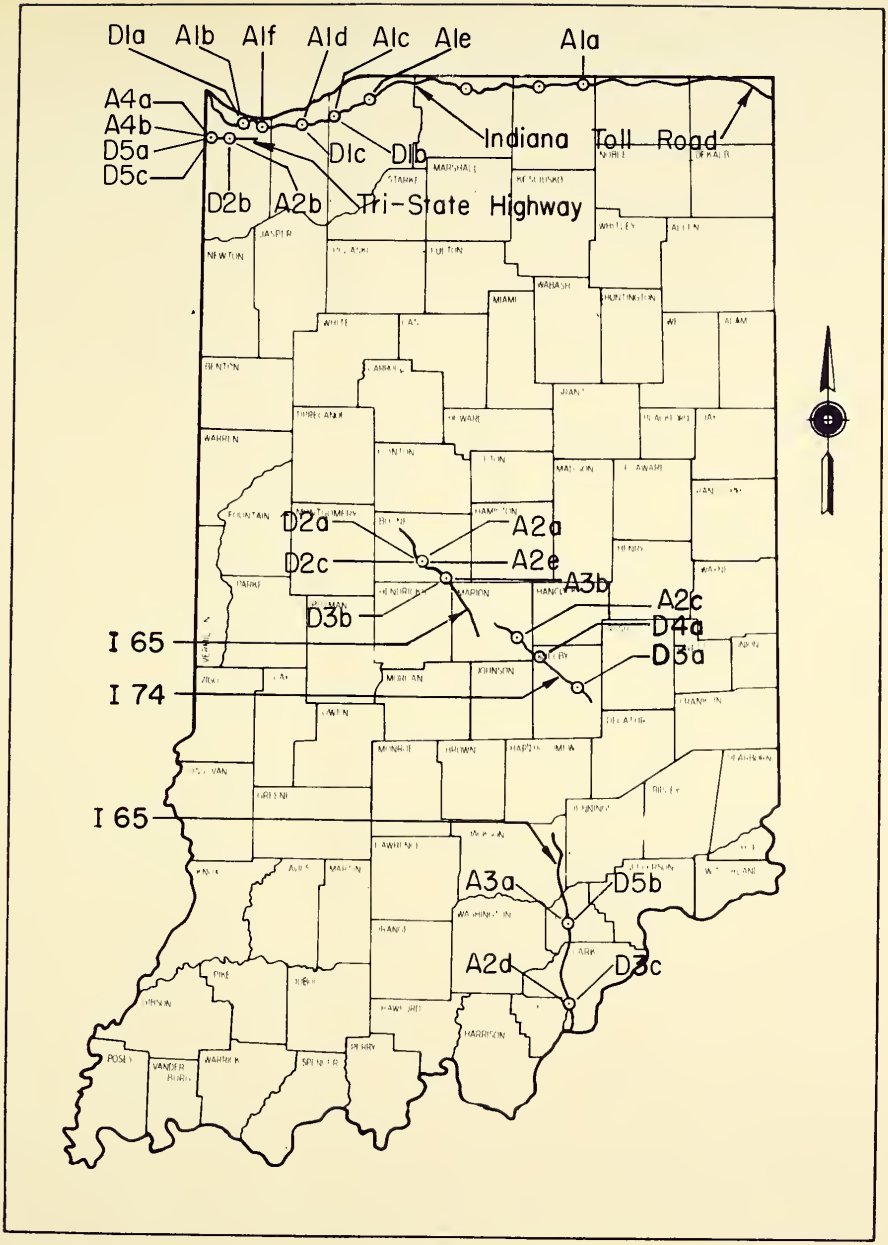

FIGURE 1. STUDY LOCATIONS OF ACCELERATION AND DECELERATION LANES

TYPICAL ACCELERATION LANE
INDIANA TOLL ROAD

TYPE I

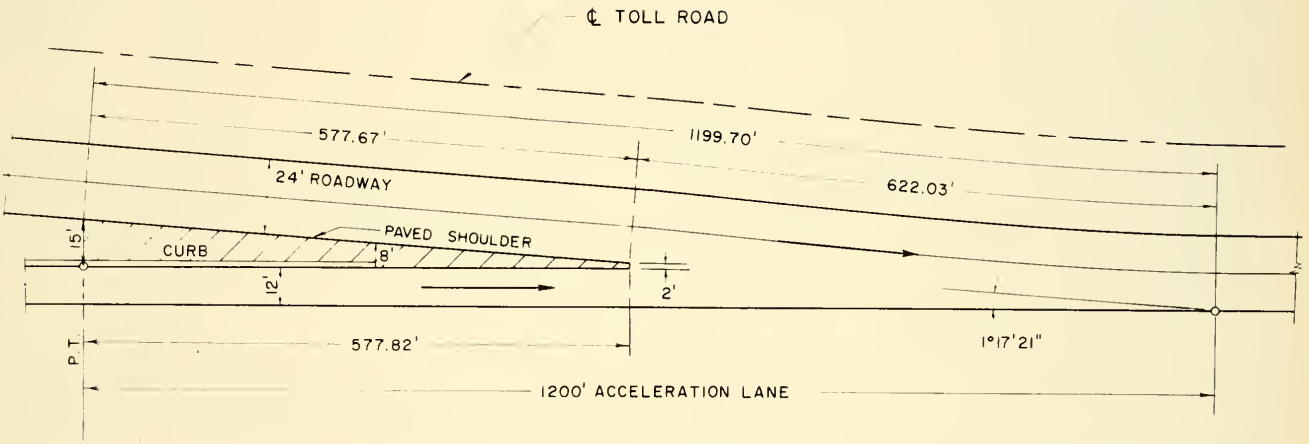

FIGURE 2

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE - WEST BOUND
INDIANA TOLL ROAD
MIDDLEBURY INTERCHANGE

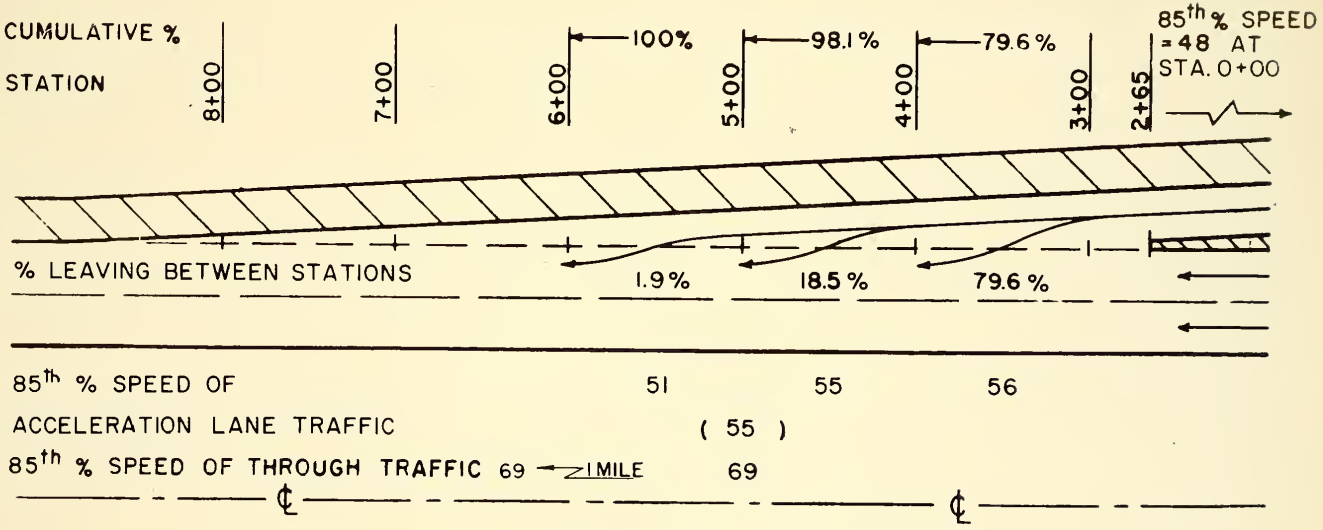

FIGURE 3

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE-WEST BOUND
INDIANA TOLL ROAD
GARY-WEST INTERCHANGE

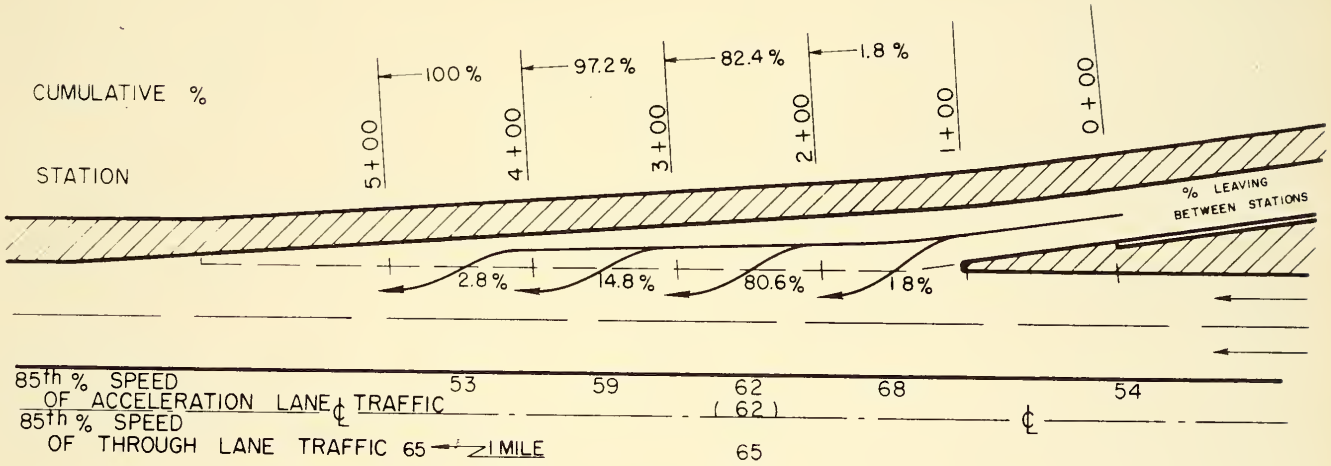

FIGURE 4

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE - WEST BOUND
INDIANA TOLL ROAD
MICHIGAN CITY INTERCHANGE

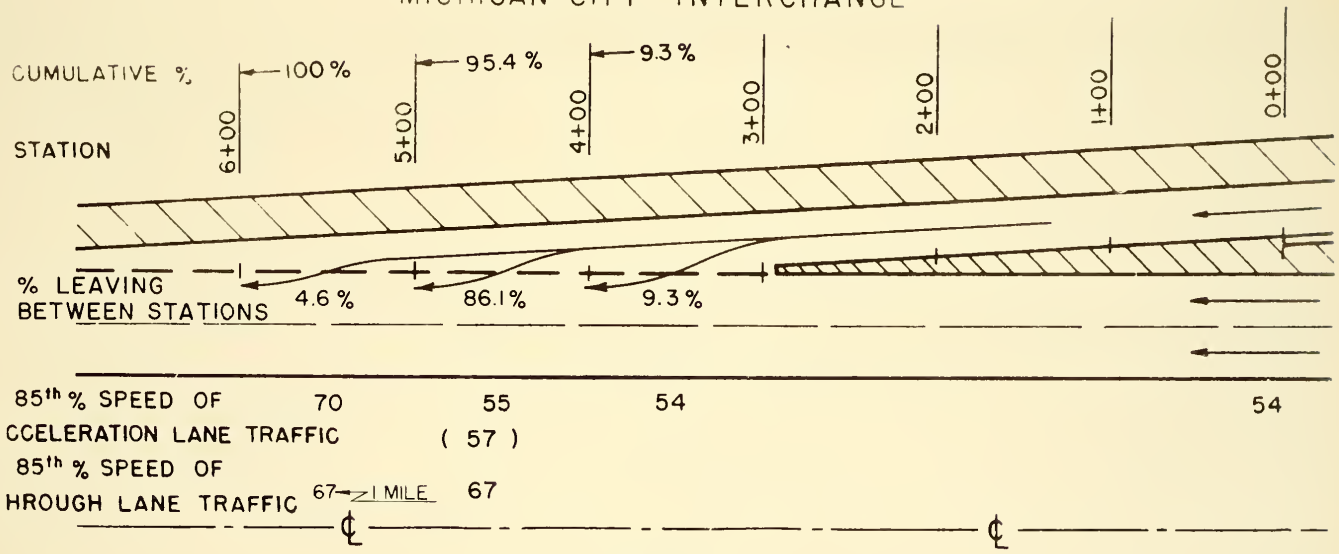

FIGURE 5

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE - WEST BOUND
INDIANA TOLL ROAD
CHESTERTON-VALPARAISO INTERCHANGE

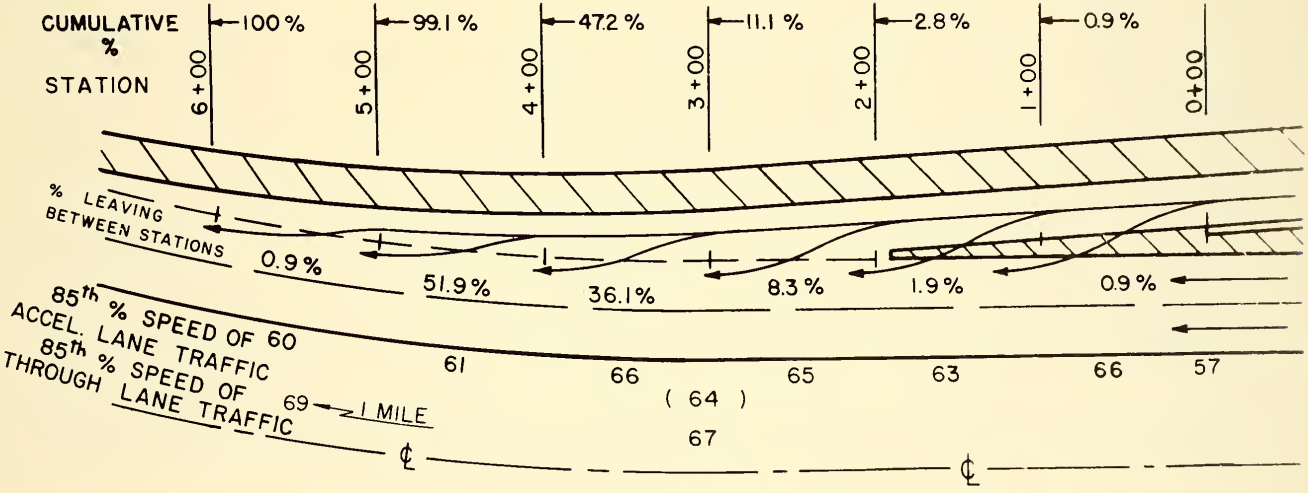

FIGURE 6

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE - WEST BOUND
INDIANA TOLL ROAD
LA PORTE INTERCHANGE

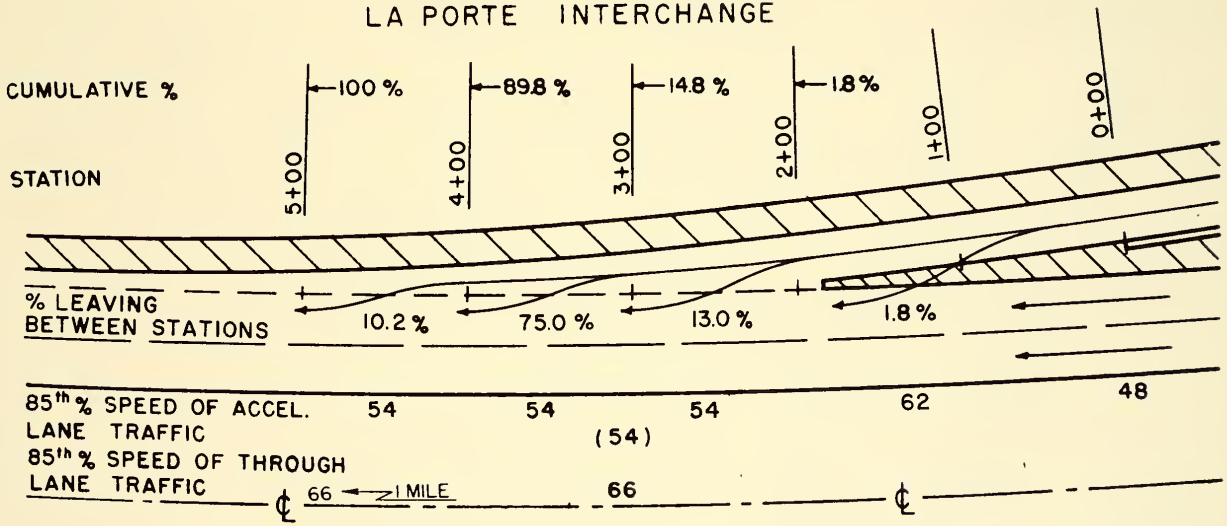

FIGURE 7

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

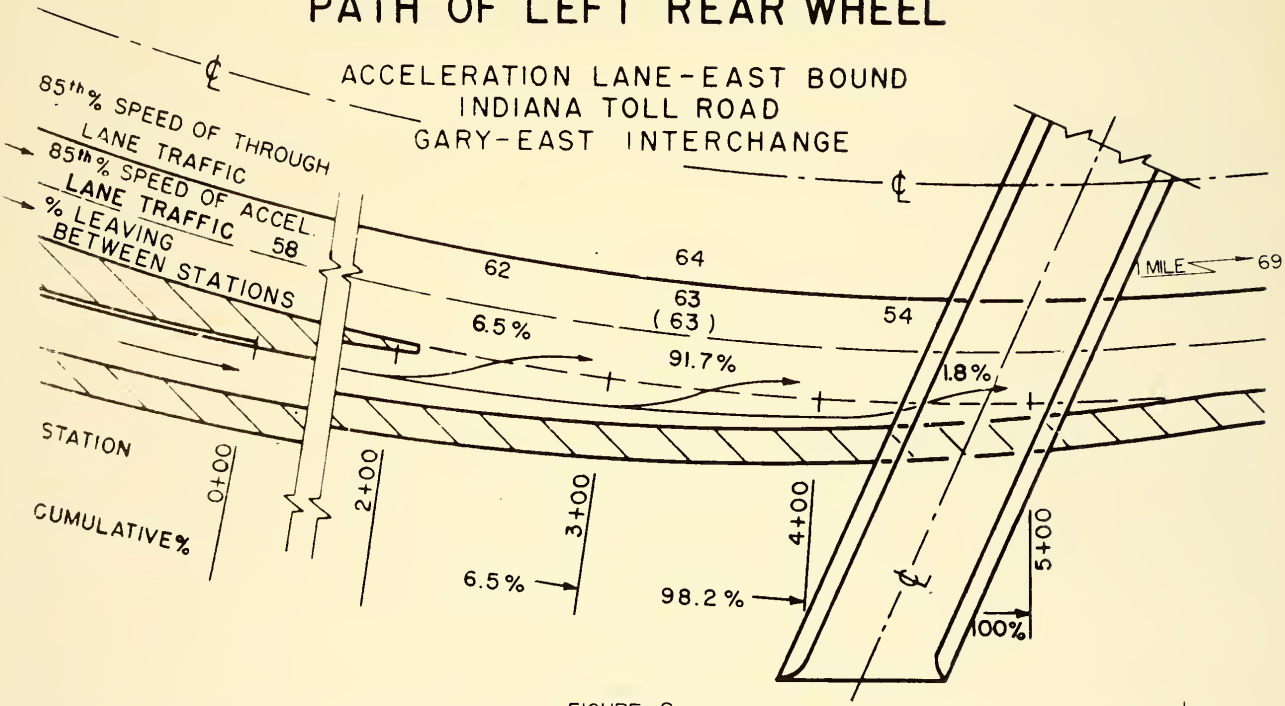

FIGURE 8

TYPICAL STANDARD ACCELERATION LANE

TYPE 2

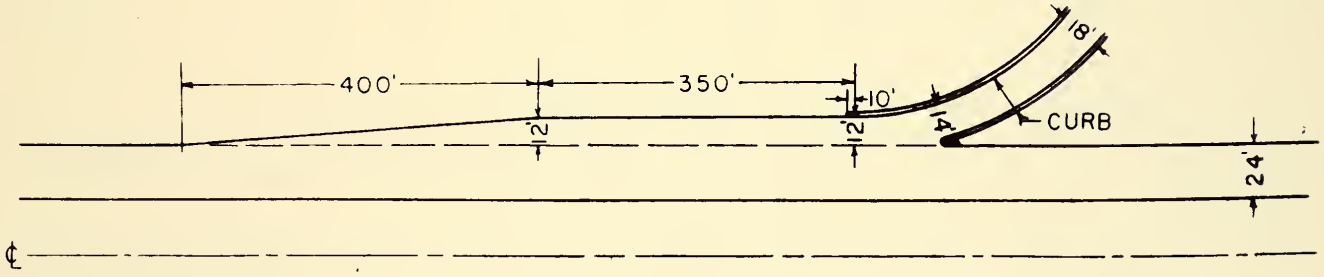

FIGURE 9

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE-NORTH BOUND
INTERSTATE 65
STATE ROUTE 39 INTERCHANGE

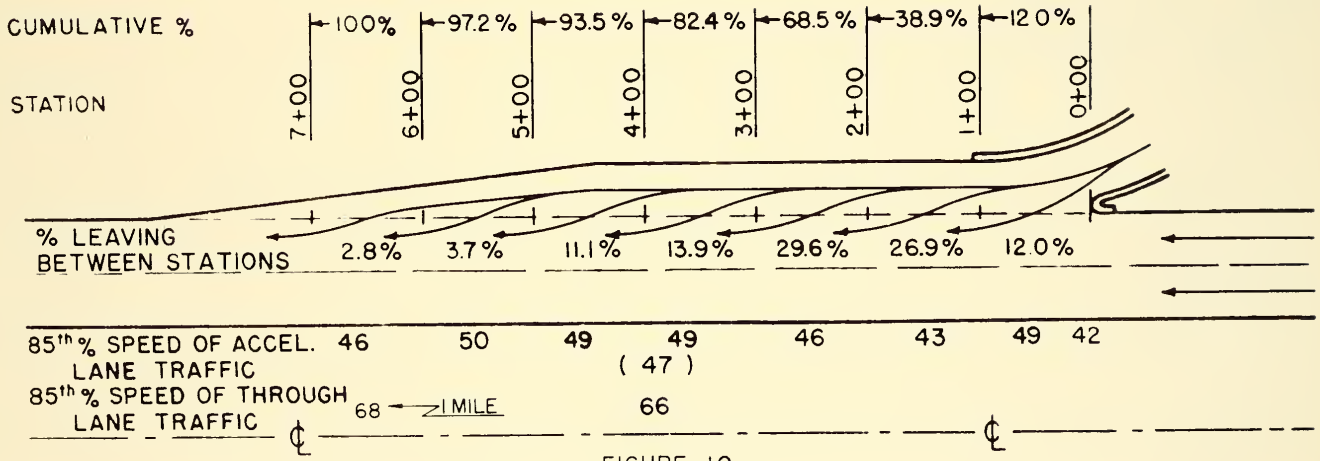

FIGURE 10

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE - EAST BOUND

TRI-STATE HIGHWAY AND KENNEDY AVENUE INTERCHANGE

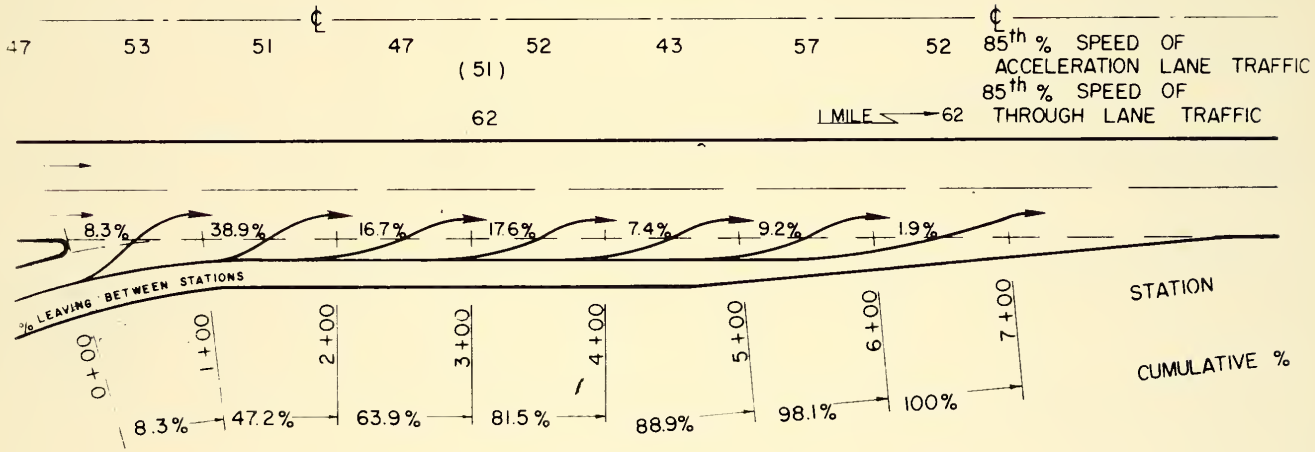

FIGURE 11

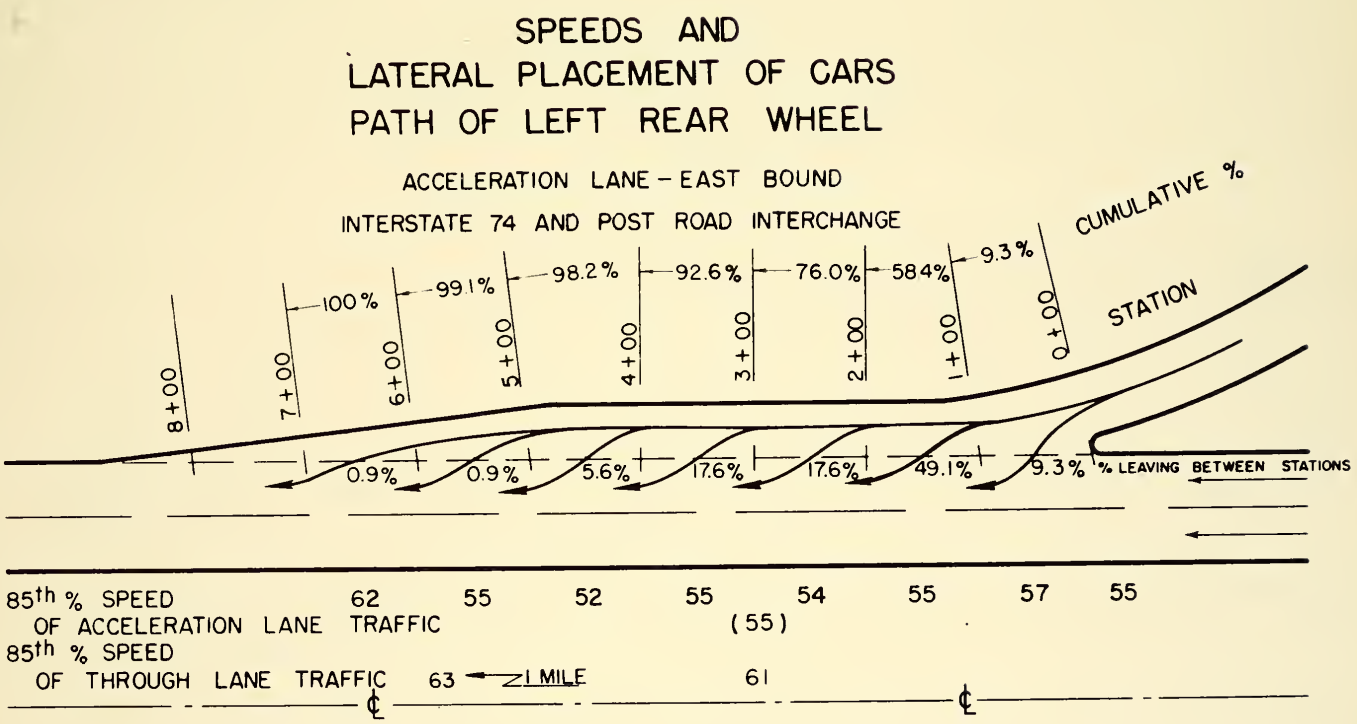
SPEEDS AND
LATERAL PLACEMENT OF CARS
PATH OF LEFT REAR WHEEL
ACCELERATION LANE – EAST BOUND
INTERSTATE 74 AND POST ROAD INTERCHANGE
CUMULATIVE %
STATION
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
100 %
99.1%
98.2%
92.6%
76.0%
58.4%
9.3%
0.9%
0.9%
5.6%
17.6%
17.6%
49.1%
9.3%
% LEAVING BETWEEN STATIONS
85th % SPEED OF ACCELERATION LANE TRAFFIC
62
55
52
55
54
55
57
55
(55)
85th % SPEED OF THROUGH LANE TRAFFIC
63
1 MILE
61

FIGURE 12

SPEEDS AND
LATERAL PLACEMENT OF CARS
PATH OF LEFT REAR WHEEL

ACCELERATION LANE-SOUTH BOUND

INTERSTATE 65 AND S.R. 60 INTERCHANGE

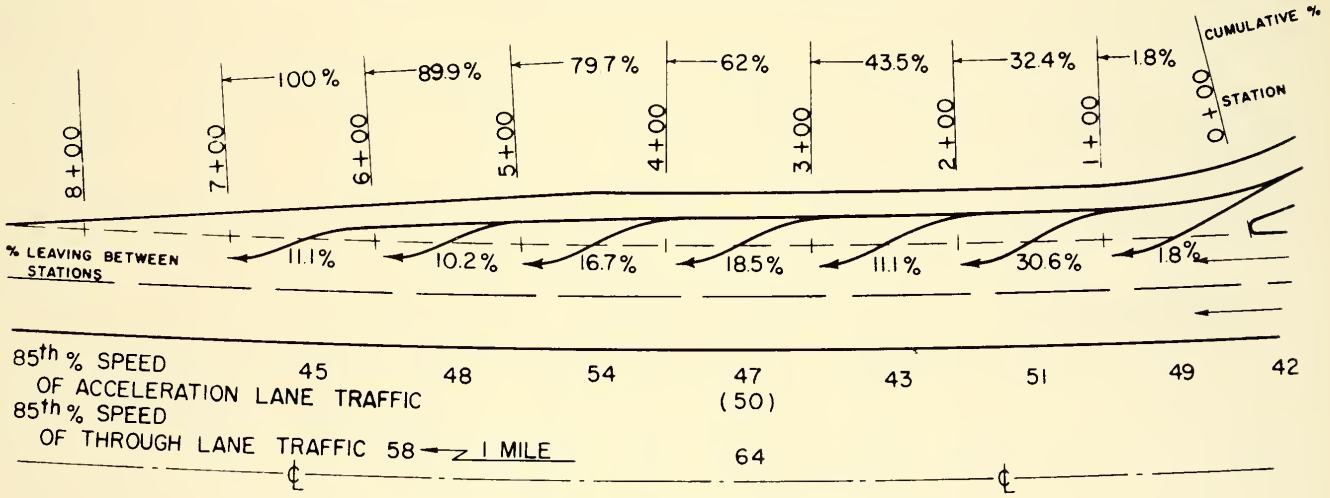

FIGURE 13

SPEEDS AND
LATERAL PLACEMENT OF CARS
PATH OF LEFT REAR WHEEL

ACCELERATION LANE-SOUTH BOUND
INTERSTATE 65
STATE ROUTE 39 INTERCHANGE

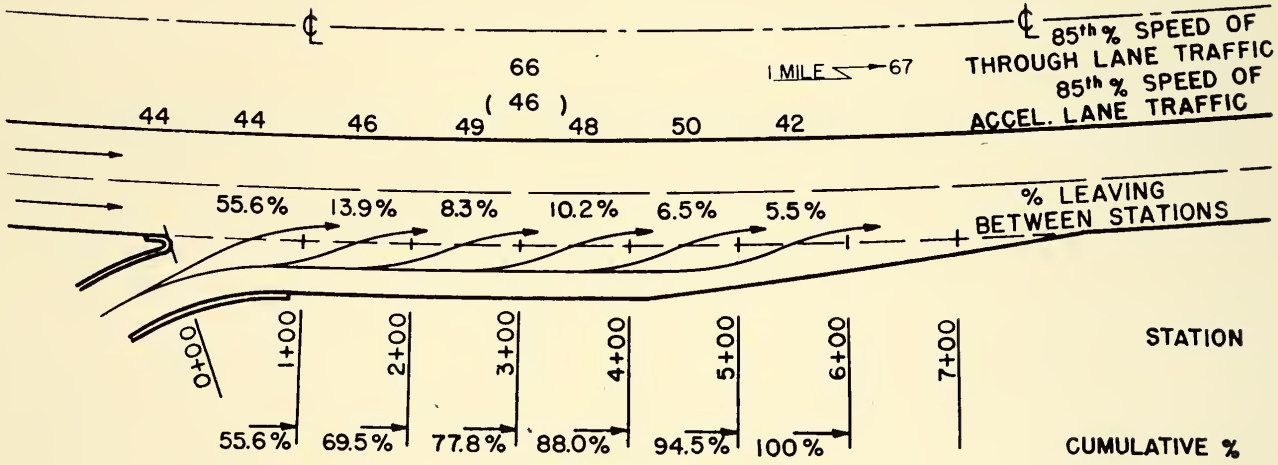

FIGURE 14

TYPICAL STANDARD ACCELERATION LANE

TYPE 3

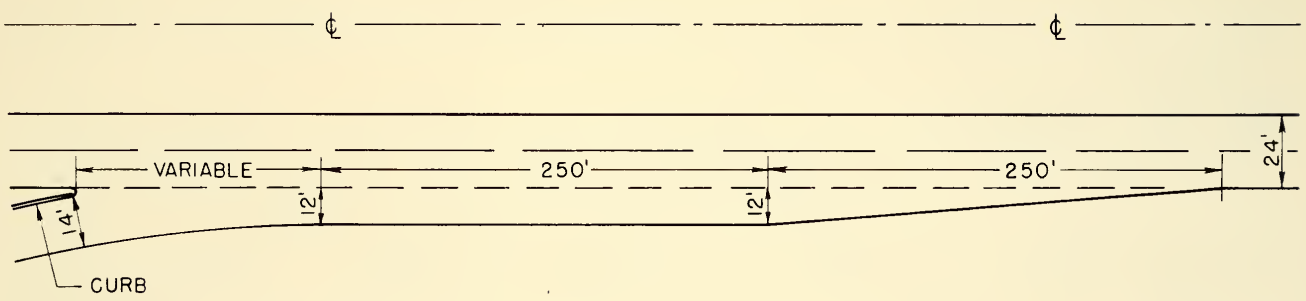

FIGURE 15

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE - NORTH BOUND

INTERSTATE 65 AND S.R. 56 INTERCHANGE

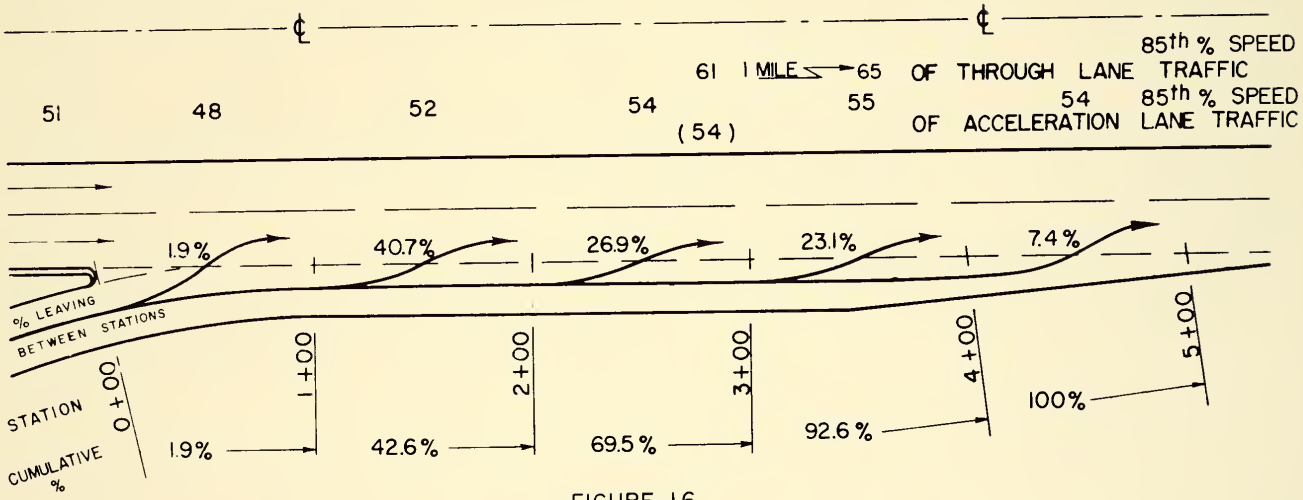

FIGURE 16

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE – NORTH BOUND

INTERSTATE 65 AND S.R. 334 INTERCHANGE

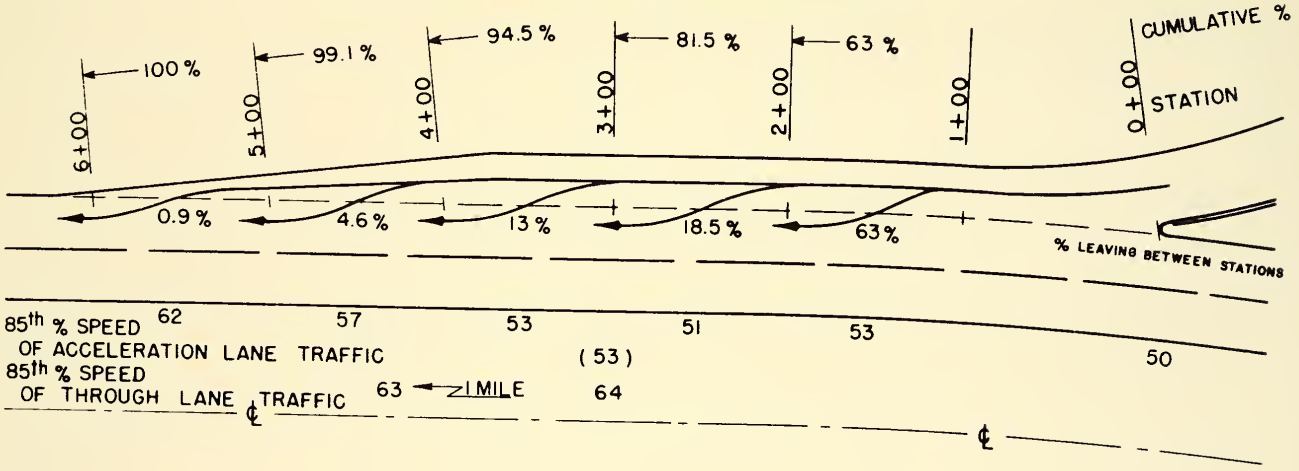

FIGURE 17

TYPICAL STANDARD ACCELERATION LANE

TYPE 4

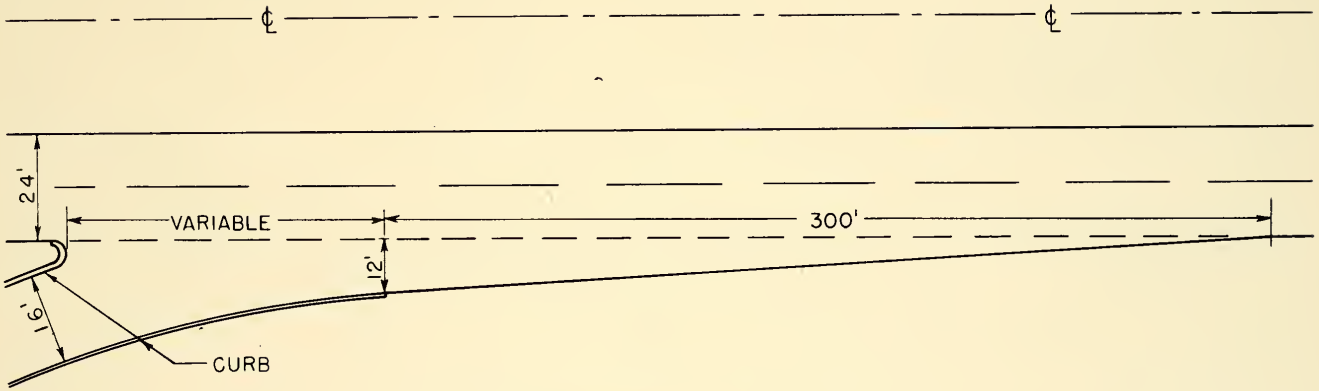

FIGURE 18

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE – EAST BOUND
TRI-STATE HIGHWAY AND CALUMET AVENUE
INTERCHANGE

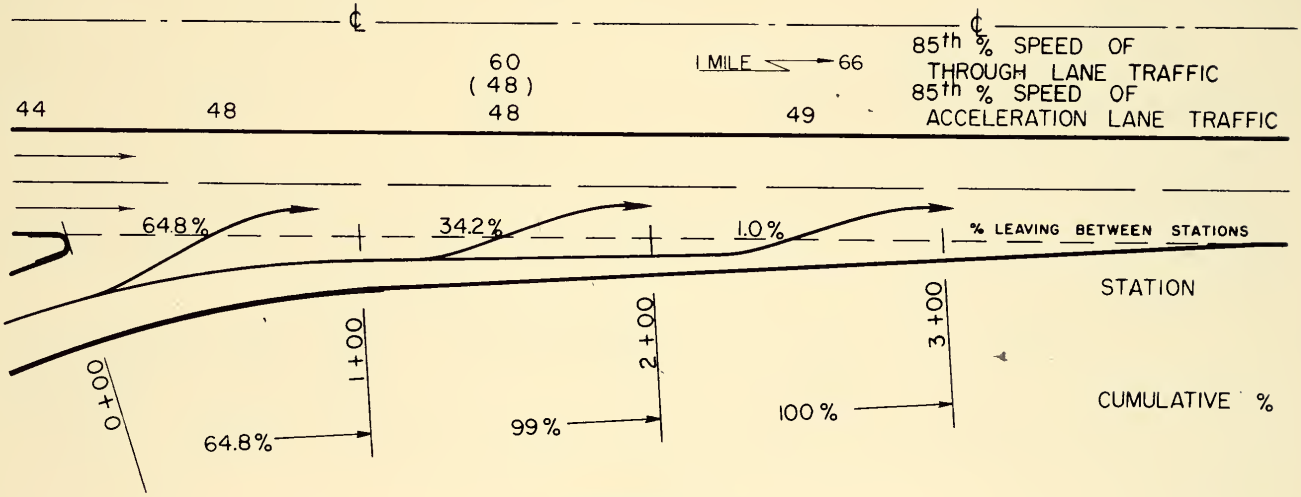

FIGURE 19

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE-WEST BOUND

TRI-STATE HIGHWAY AND CALUMET AVENUE

INTERCHANGE

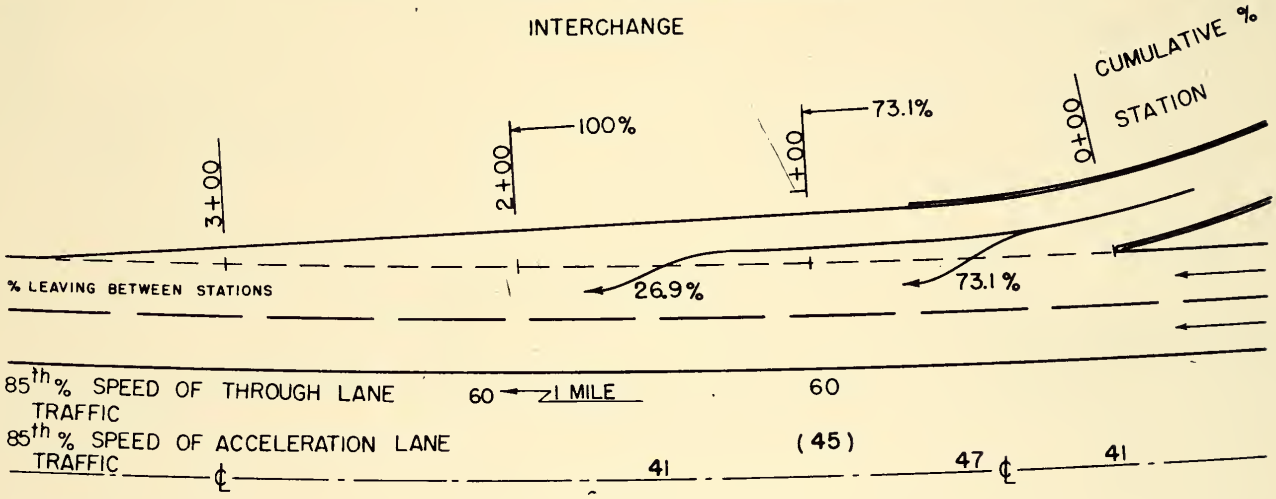

FIGURE 20

TYPICAL DECELERATION LANE

INDIANA TOLL ROAD

TYPE I

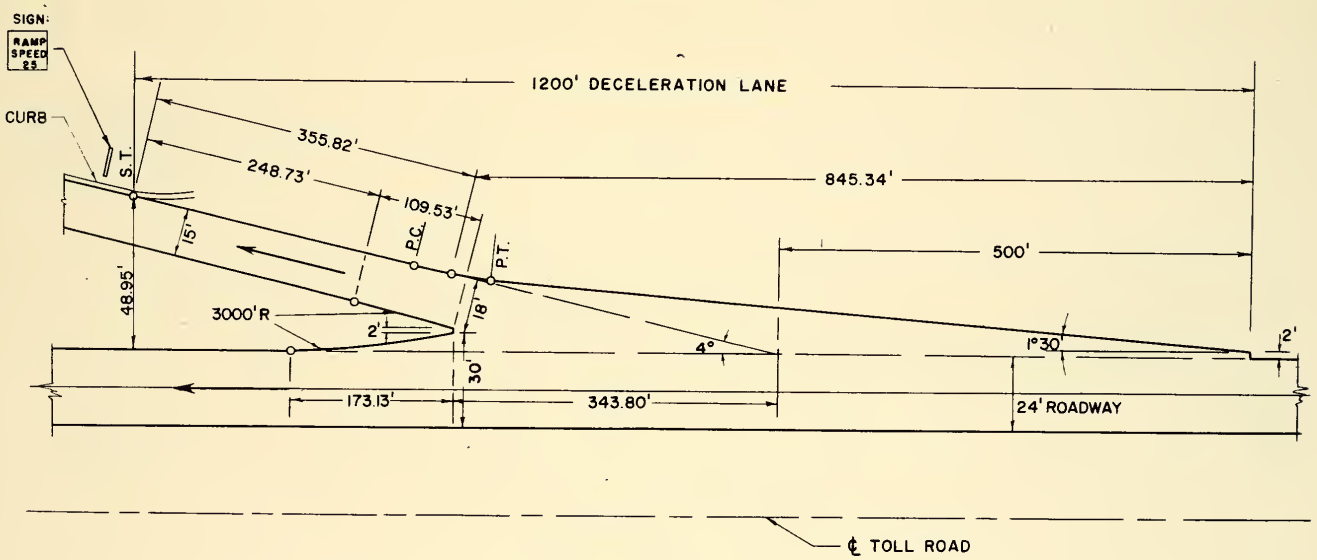

FIGURE 21

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE - EAST BOUND
INDIANA TOLL ROAD
GARY - WEST INTERCHANGE

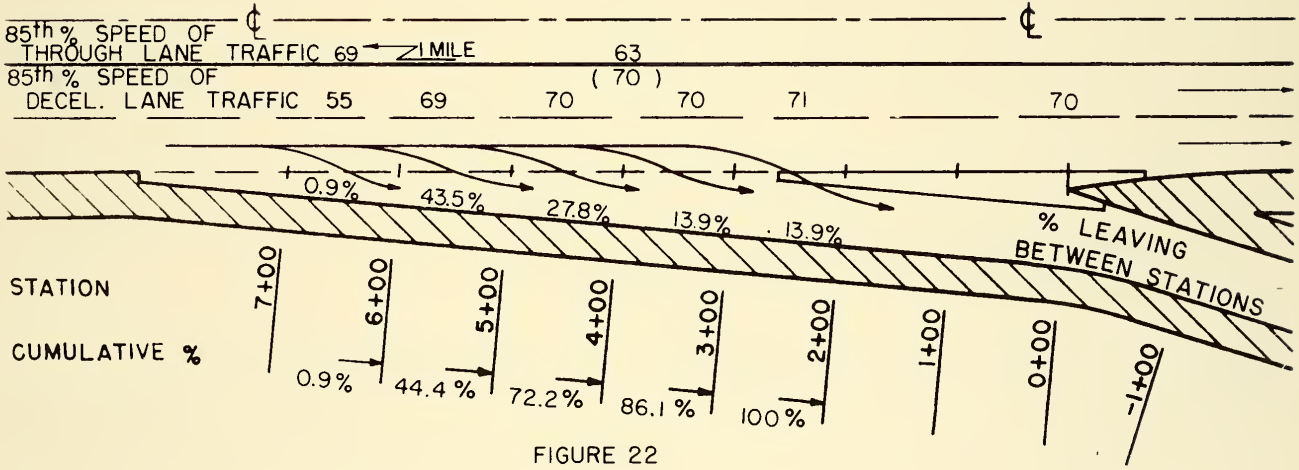

FIGURE 22

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE - WEST BOUND
INDIANA TOLL ROAD
MICHIGAN CITY INTERCHANGE

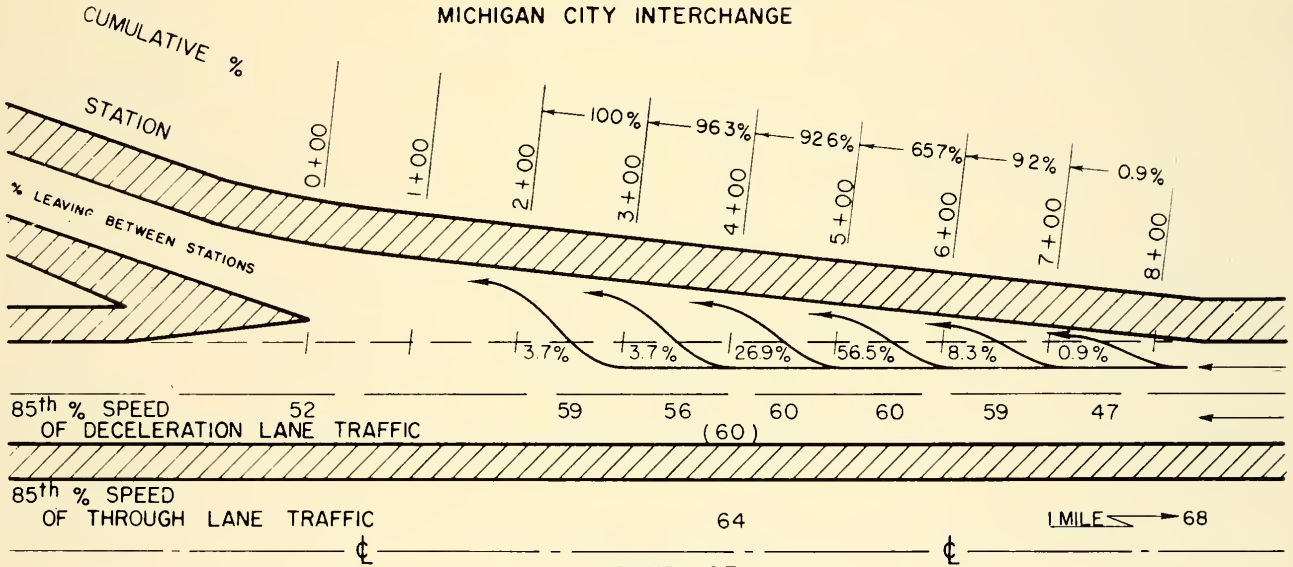

FIGURE 23

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE - EAST BOUND
INDIANA TOLL ROAD
CHESTERTON-VALPARAISO INTERCHANGE

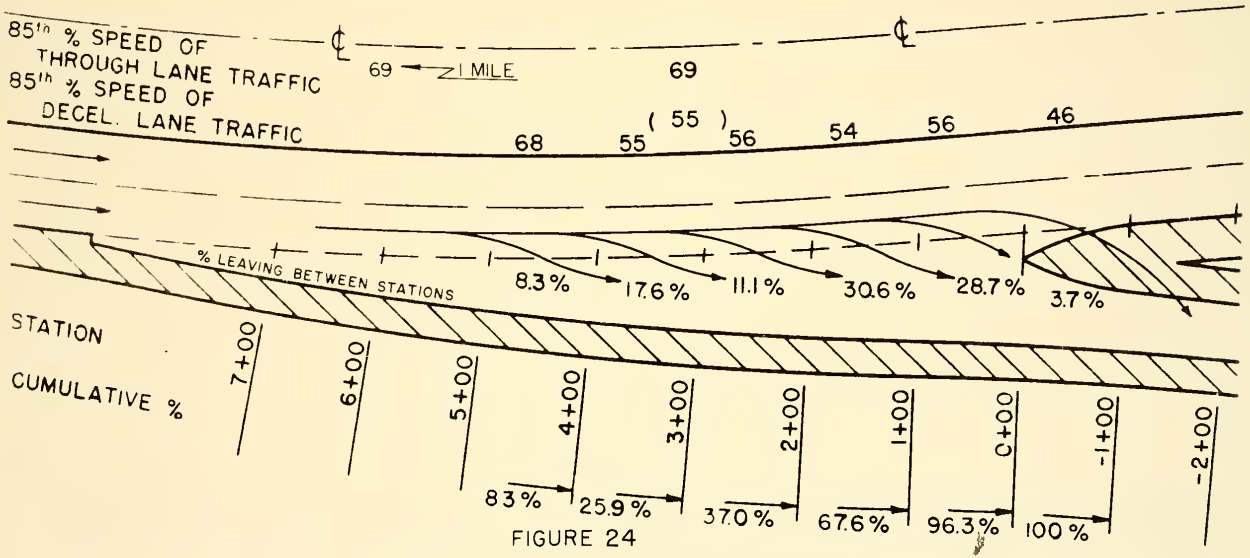

FIGURE 24

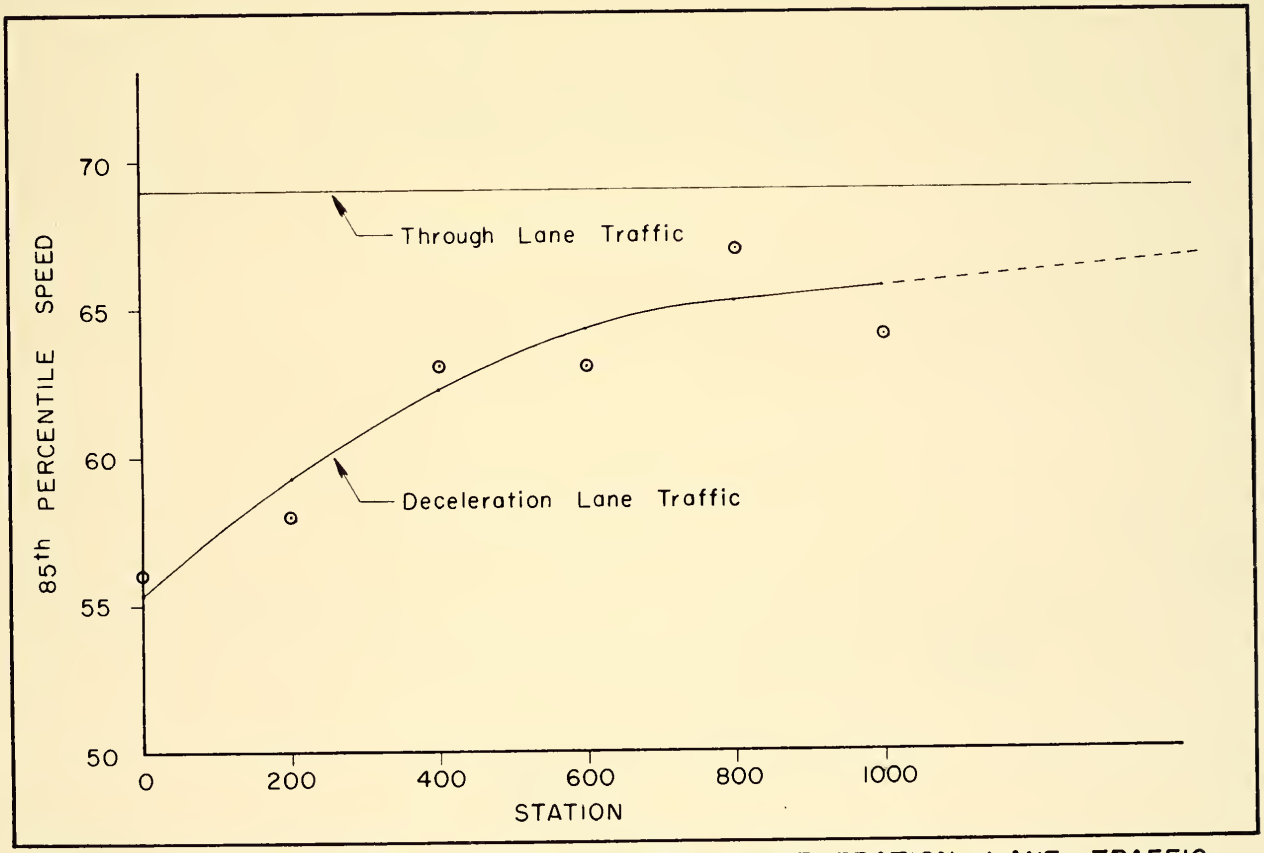

FIGURE 25. DETERMINATION OF POINT WHERE DECELERATION LANE TRAFFIC BEGINS TO DECELERATE ON THROUGH LANE–LOCATION D Ic

TYPICAL STANDARD DECELERATION LANE

TYPE 2

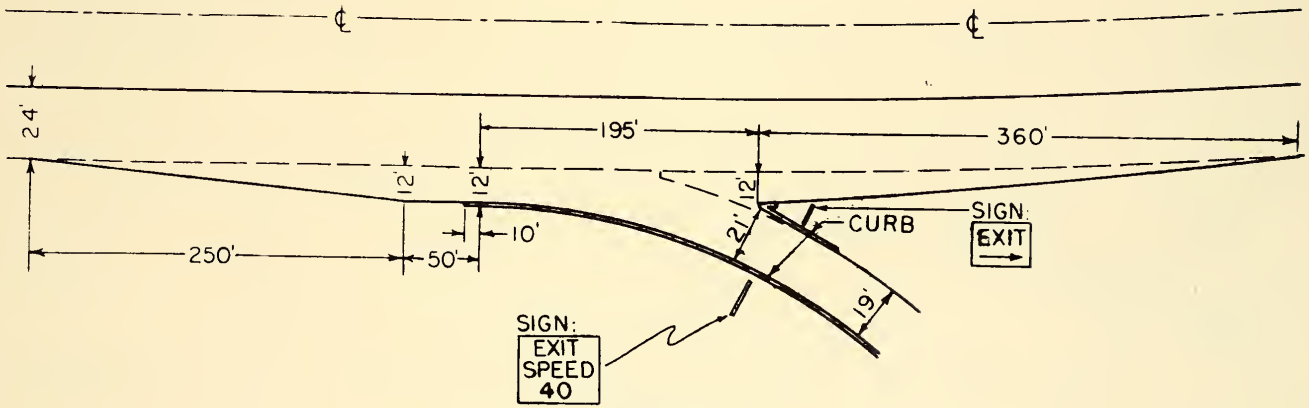

FIGURE 26

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE-SOUTH BOUND
INTERSTATE 65
STATE ROUTE 39 INTERCHANGE

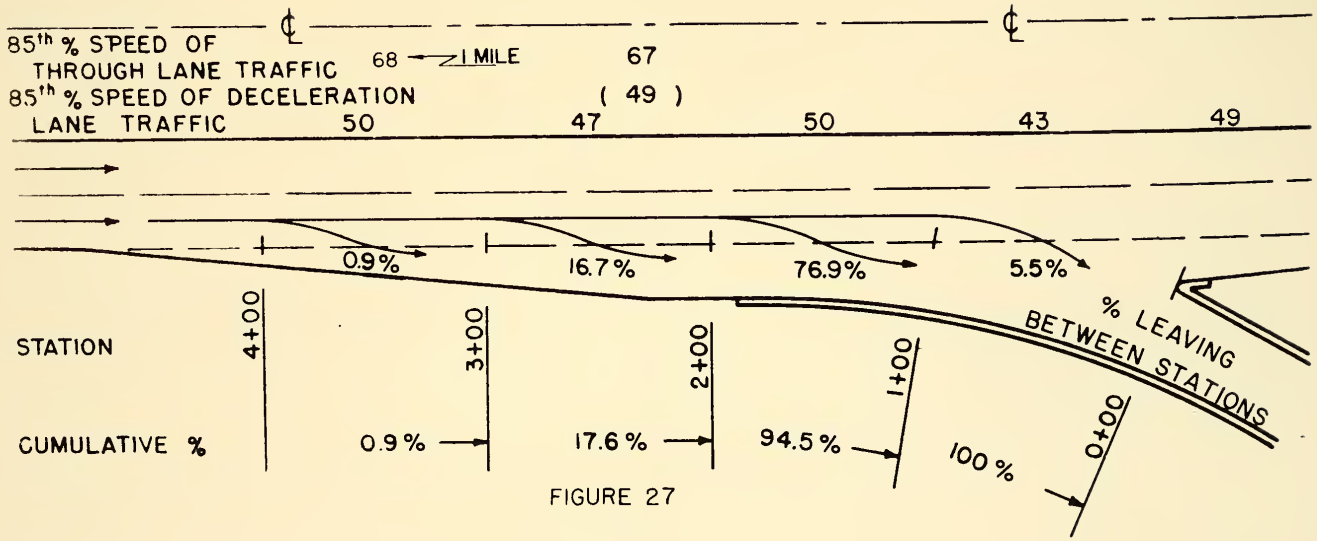

FIGURE 27

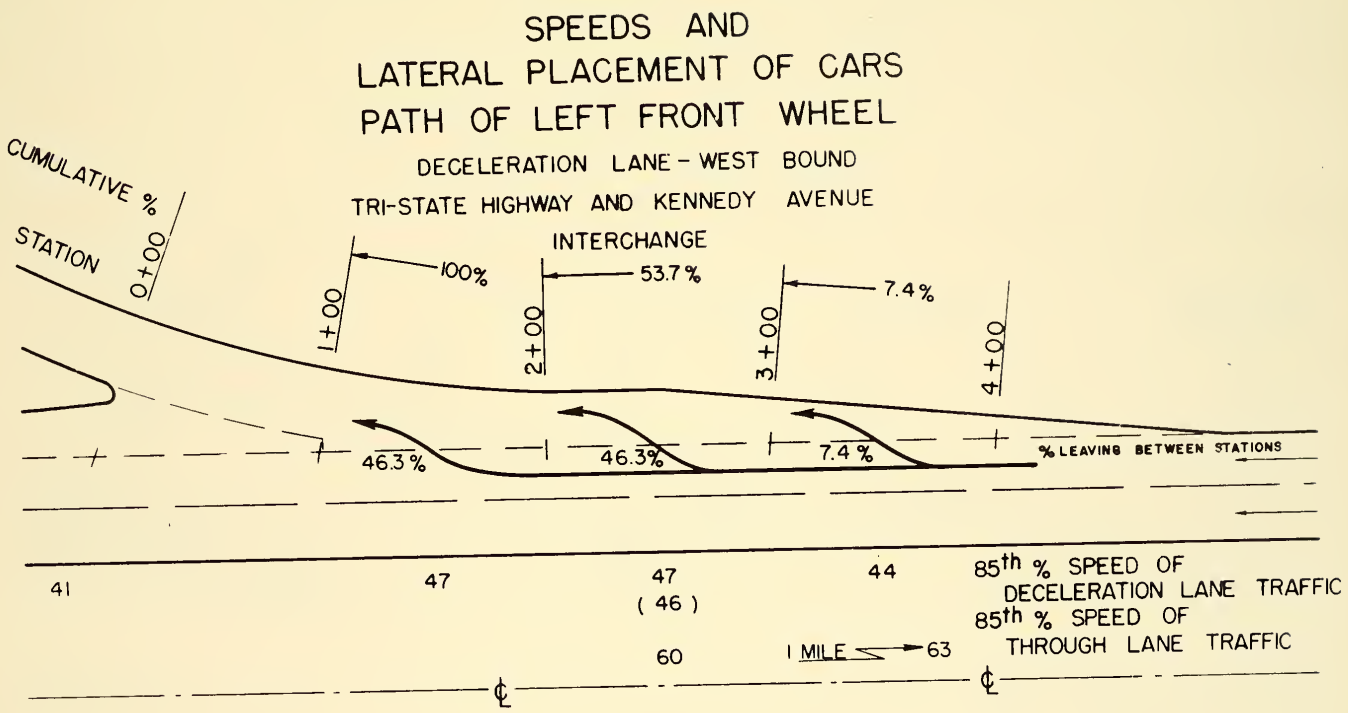
SPEEDS AND
LATERAL PLACEMENT OF CARS
PATH OF LEFT FRONT WHEEL
DECELERATION LANE - WEST BOUND
TRI-STATE HIGHWAY AND KENNEDY AVENUE
INTERCHANGE
CUMULATIVE %
STATION
0+00
1+00
2+00
3+00
4+00
100%
53.7%
7.4%
46.3%
46.3%
7.4%
% LEAVING BETWEEN STATIONS
41
47
47
(46)
44
85th % SPEED OF
DECELERATION LANE TRAFFIC
85th % SPEED OF
THROUGH LANE TRAFFIC
60
1 MILE
63
℄
℄

FIGURE 28

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE-NORTH BOUND
INTERSTATE 65
STATE ROUTE 39 INTERCHANGE

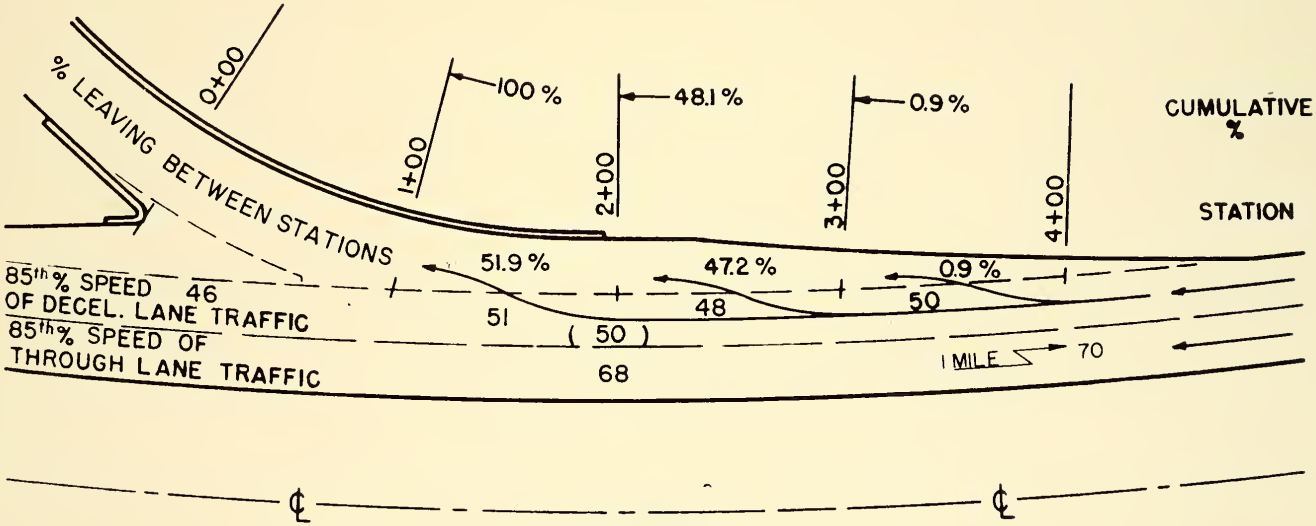

FIGURE 29

TYPICAL STANDARD DECELERATION LANE

TYPE 3

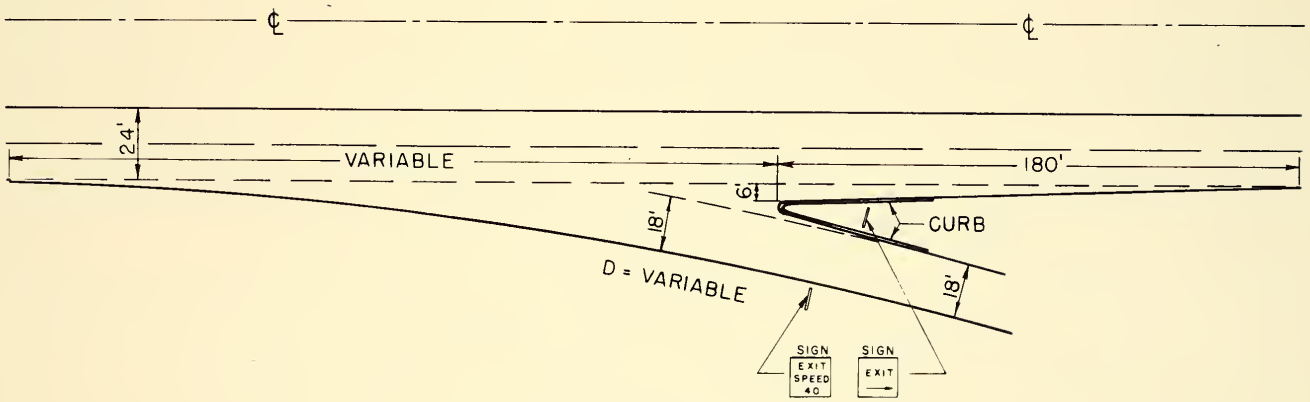

FIGURE 30

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE - EAST BOUND
INTERSTATE 74 AND STATE ROUTE 9
INTERCHANGE

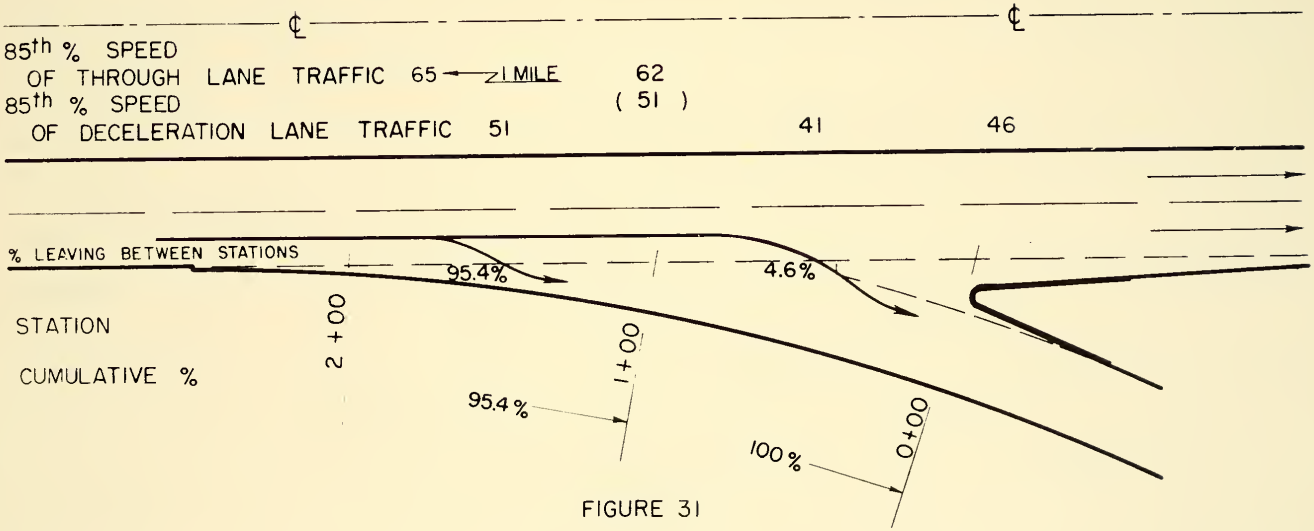

FIGURE 31

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE-SOUTH BOUND

INTERSTATE 65 AND S.R. 334 INTERCHANGE

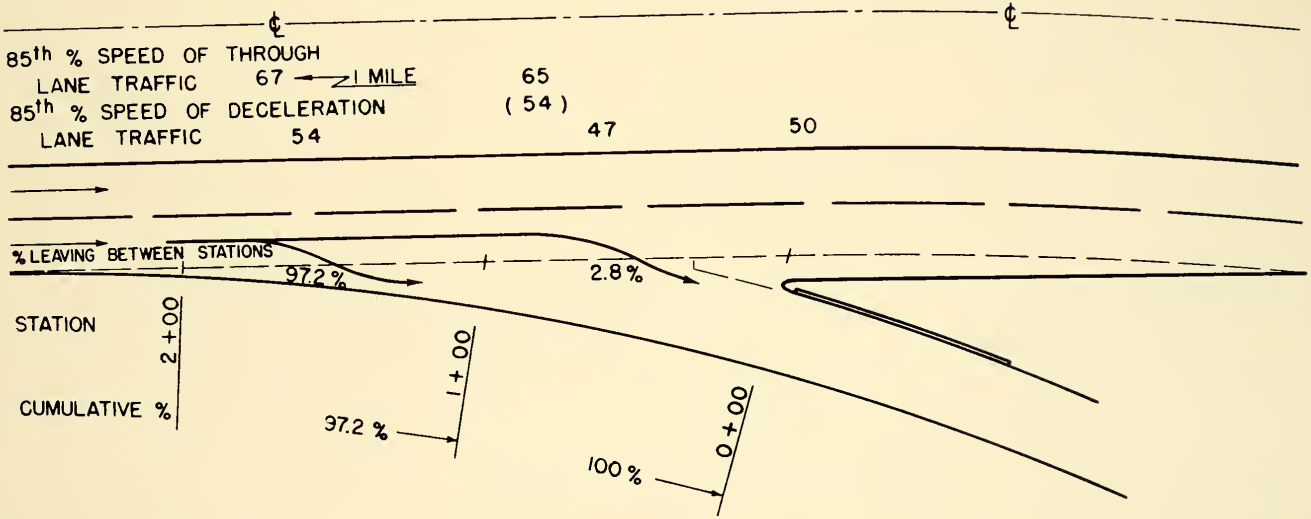

FIGURE 32

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE-NORTH BOUND

INTERSTATE 65 AND S.R. 60 INTERCHANGE

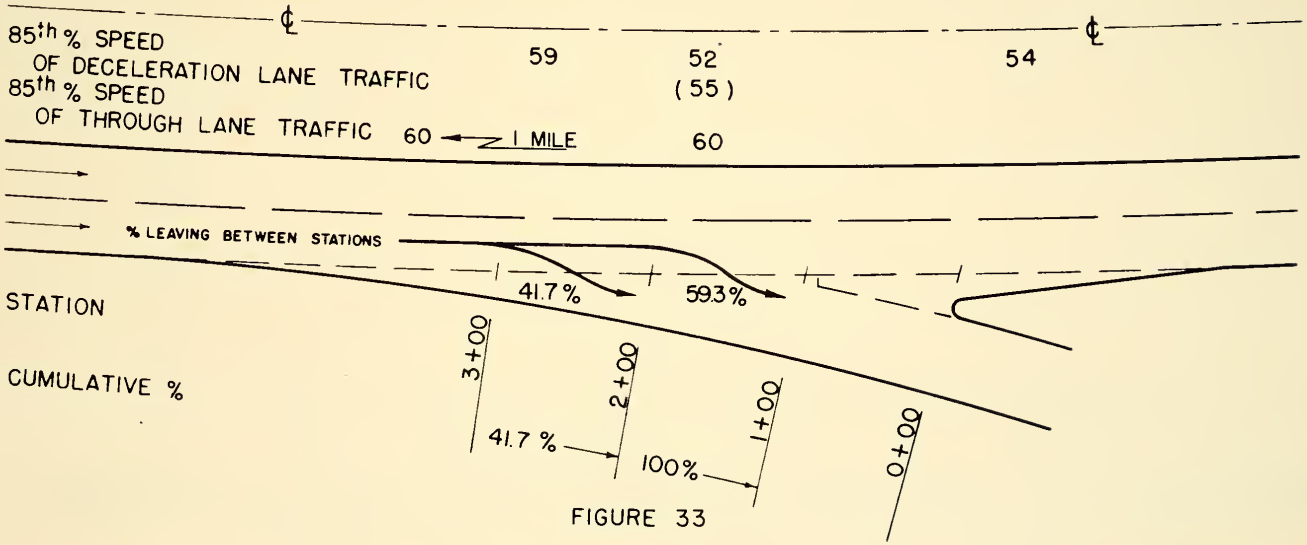

FIGURE 33

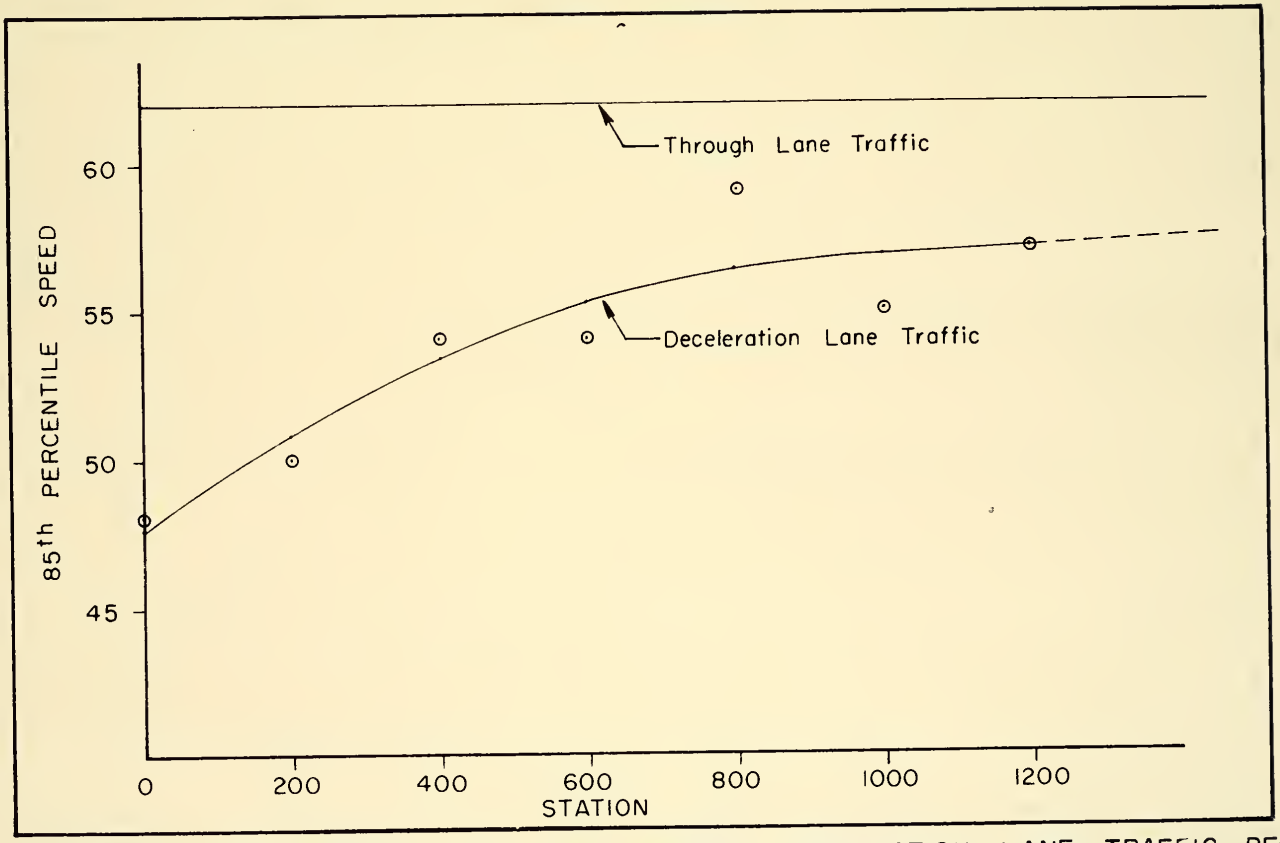

FIGURE 34. DETERMINATION OF POINT WHERE DECELERATION LANE TRAFFIC BEGINS TO DECELERATE ON THE THROUGH LANE – LOCATION D3a

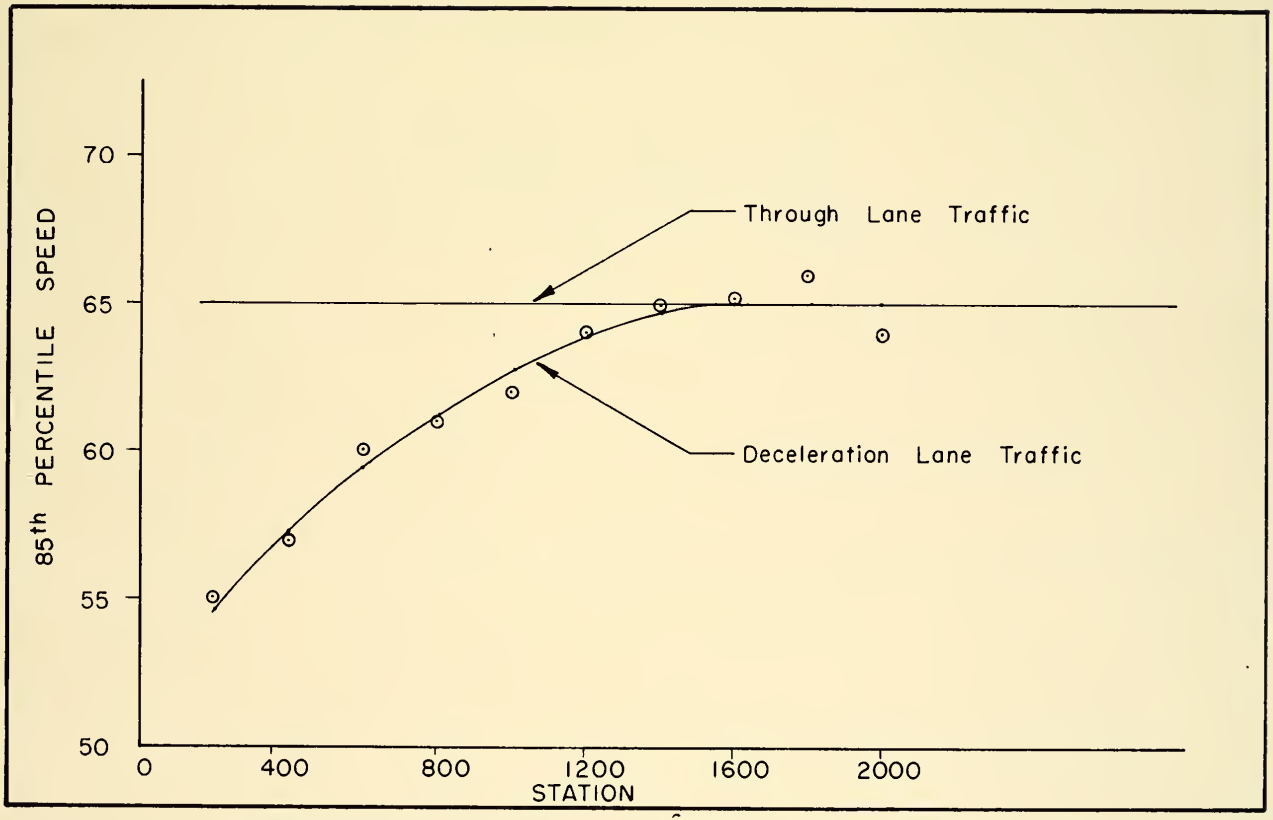

FIGURE 35. DETERMINATION OF POINT WHERE DECELERATION LANE TRAFFIC BEGINS TO DECELERATE ON THE THROUGH LANE – LOCATION D3b

TYPICAL STANDARD DECELERATION LANE

TYPE 4

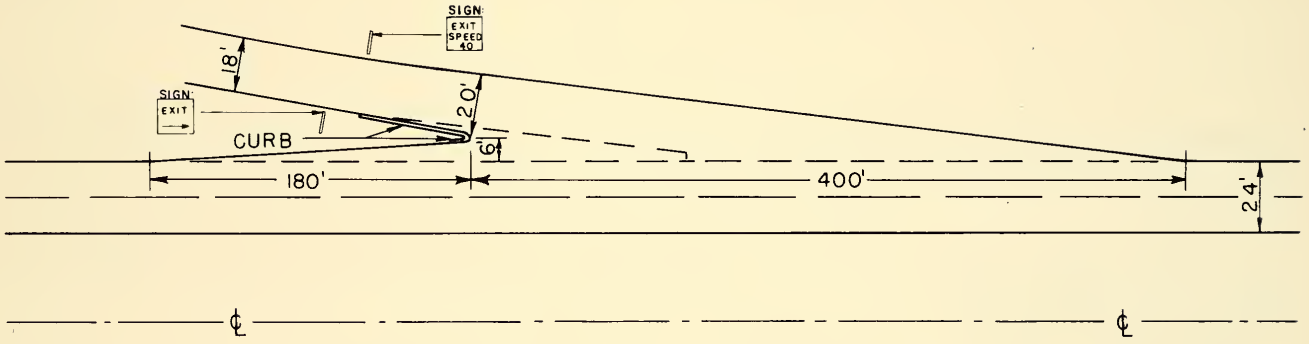

FIGURE 36

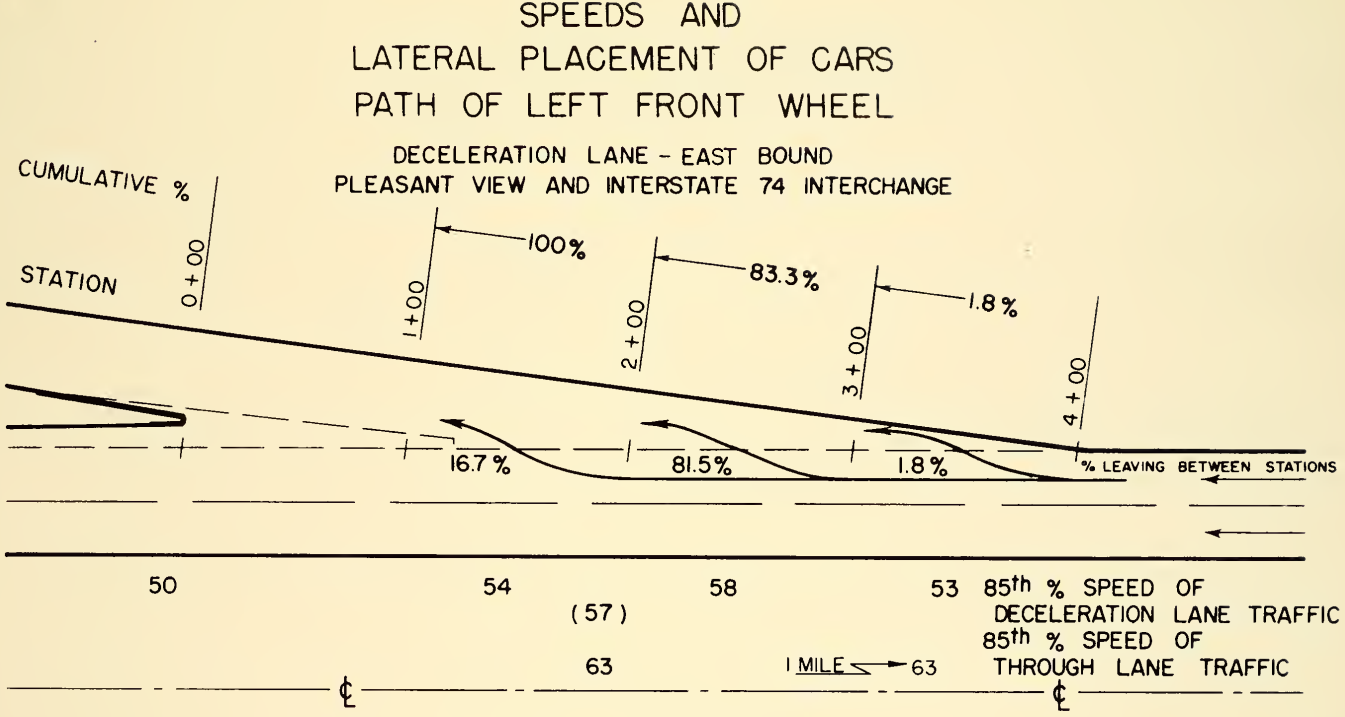
SPEEDS AND
LATERAL PLACEMENT OF CARS
PATH OF LEFT FRONT WHEEL
DECELERATION LANE - EAST BOUND
PLEASANT VIEW AND INTERSTATE 74 INTERCHANGE
CUMULATIVE %
STATION
0+00
1+00
2+00
3+00
4+00
100%
83.3%
1.8%
16.7%
81.5%
1.8%
% LEAVING BETWEEN STATIONS
50
54
58
53
(57)
63
1 MILE
63
85th % SPEED OF DECELERATION LANE TRAFFIC
85th % SPEED OF THROUGH LANE TRAFFIC

FIGURE 37

TYPICAL STANDARD DECELERATION LANE

TYPE 5

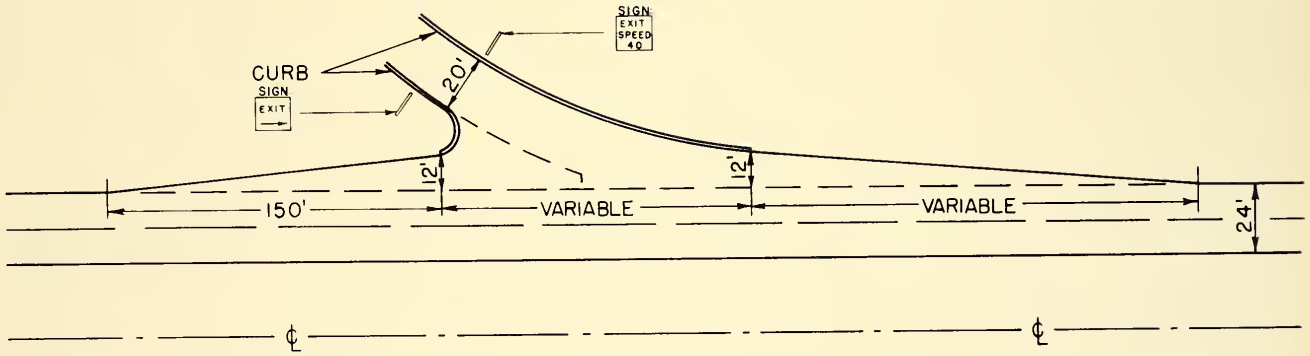

FIGURE 38

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE - WEST BOUND
TRI-STATE HIGHWAY AND CALUMET AVENUE
INTERCHANGE

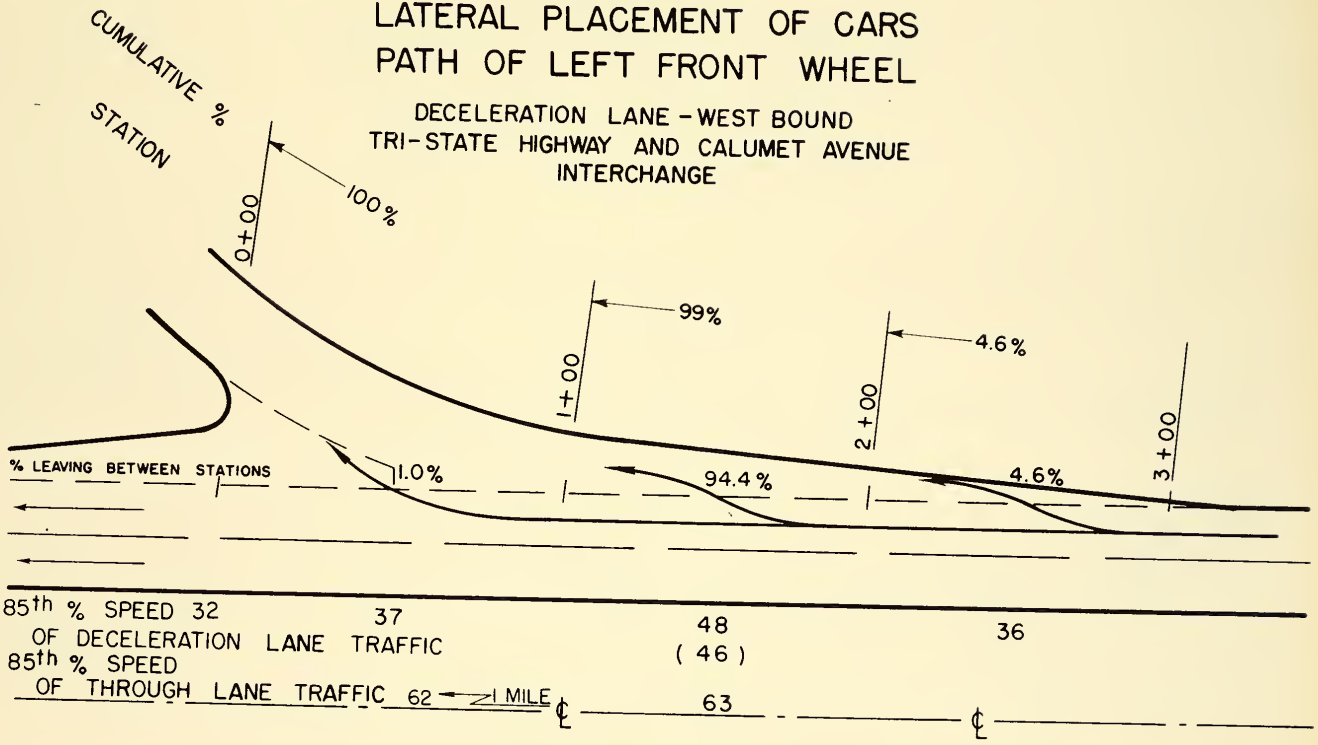

FIGURE 39

SPEEDS AND
LATERAL PLACEMENT OF CARS
PATH OF LEFT FRONT WHEEL

DECELERATION LANE-NORTH BOUND

INTERSTATE 65 AND S.R. 56 INTERCHANGE

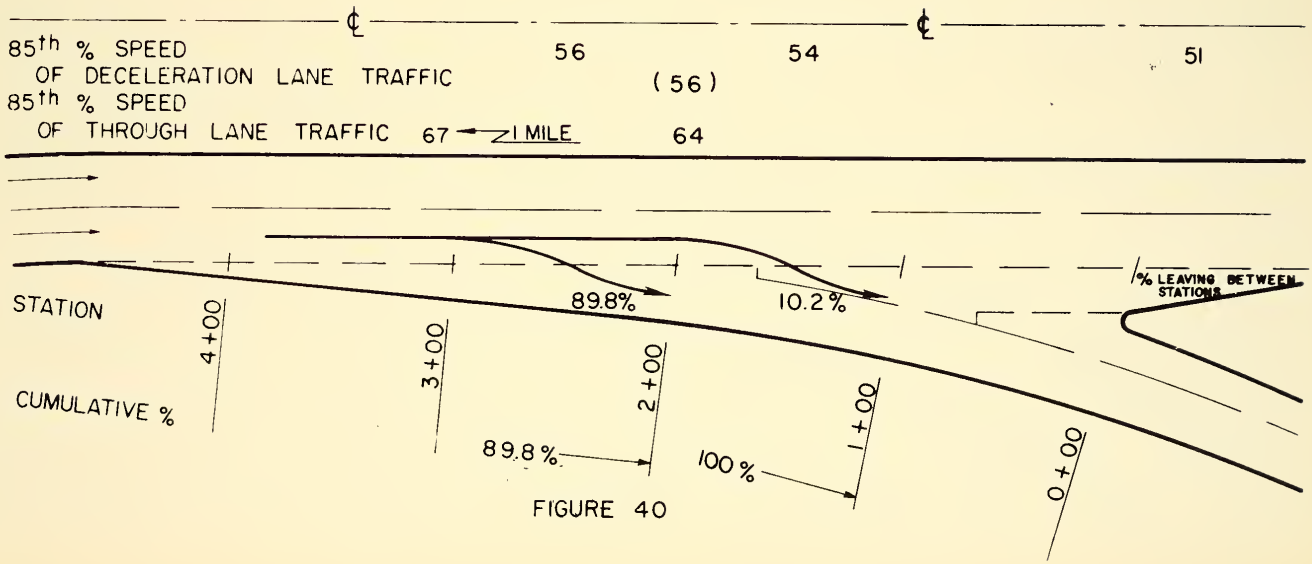

FIGURE 40

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE-EAST BOUND

TRI-STATE HIGHWAY AND CALUMET AVENUE

INTERCHANGE

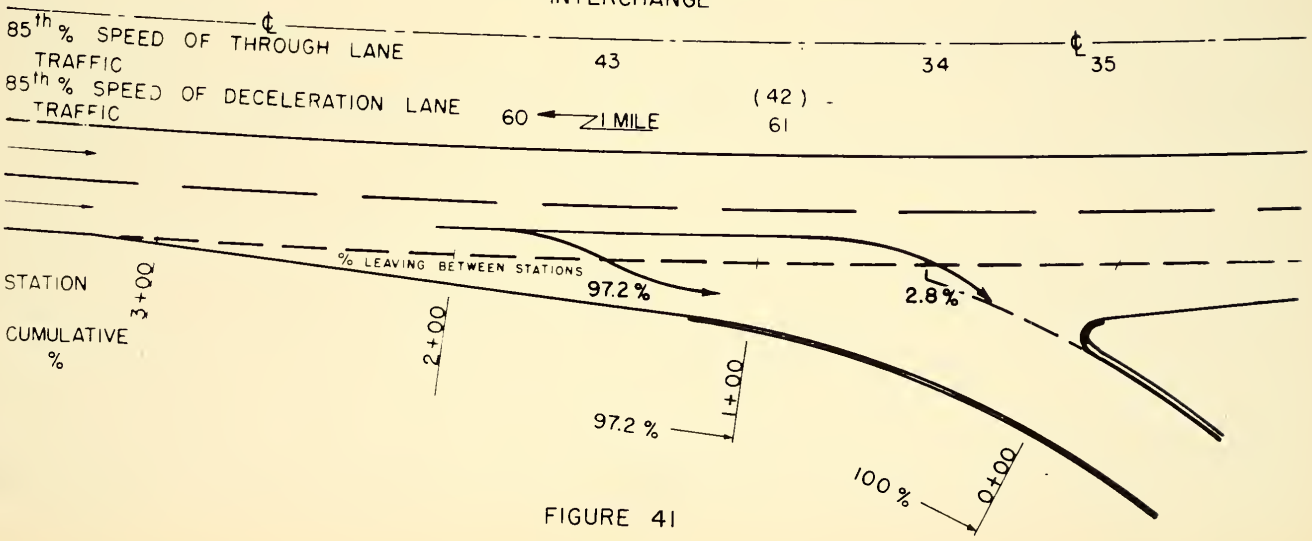

FIGURE 41

PROPOSED STANDARD ACCELERATION LANE

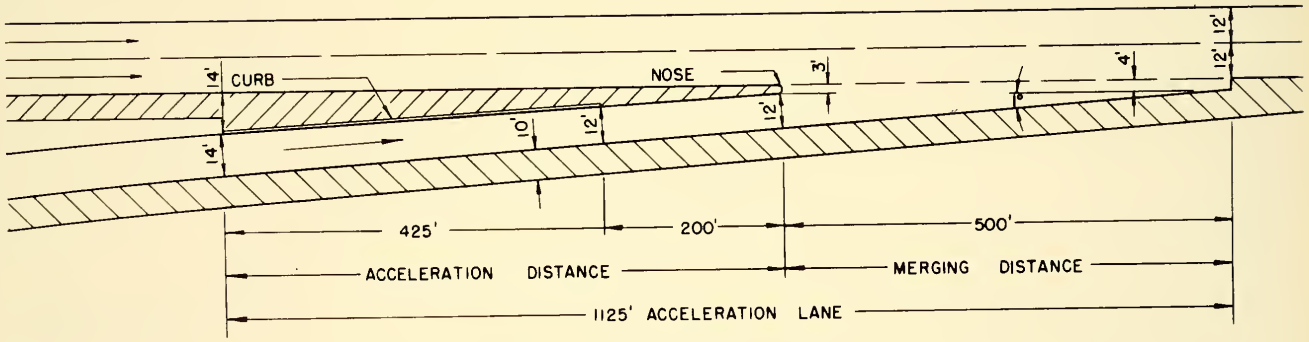

FIGURE 42

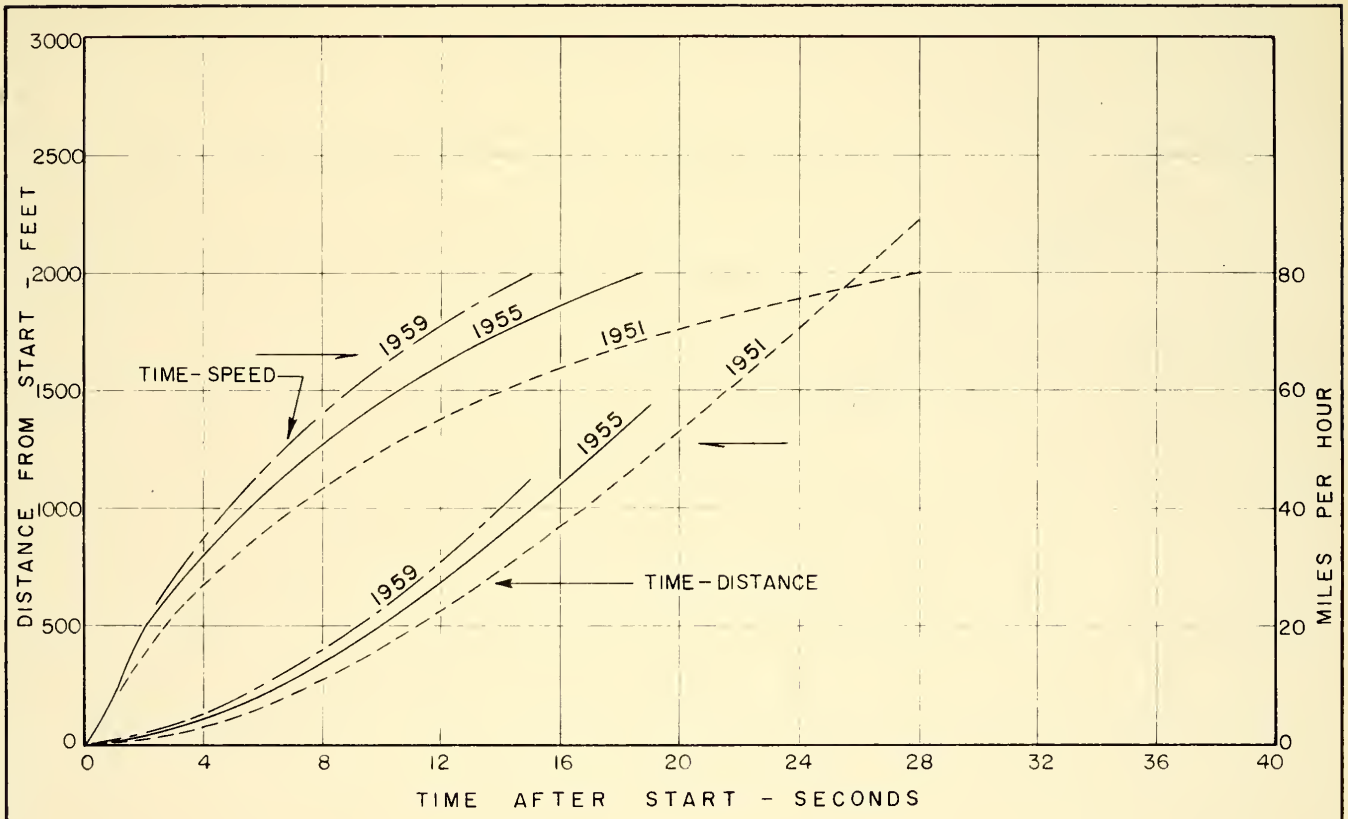

Figure 43. - Time-Distance and Time-Speed Comparison of the Best Performing Cars for Three Model Years (29)

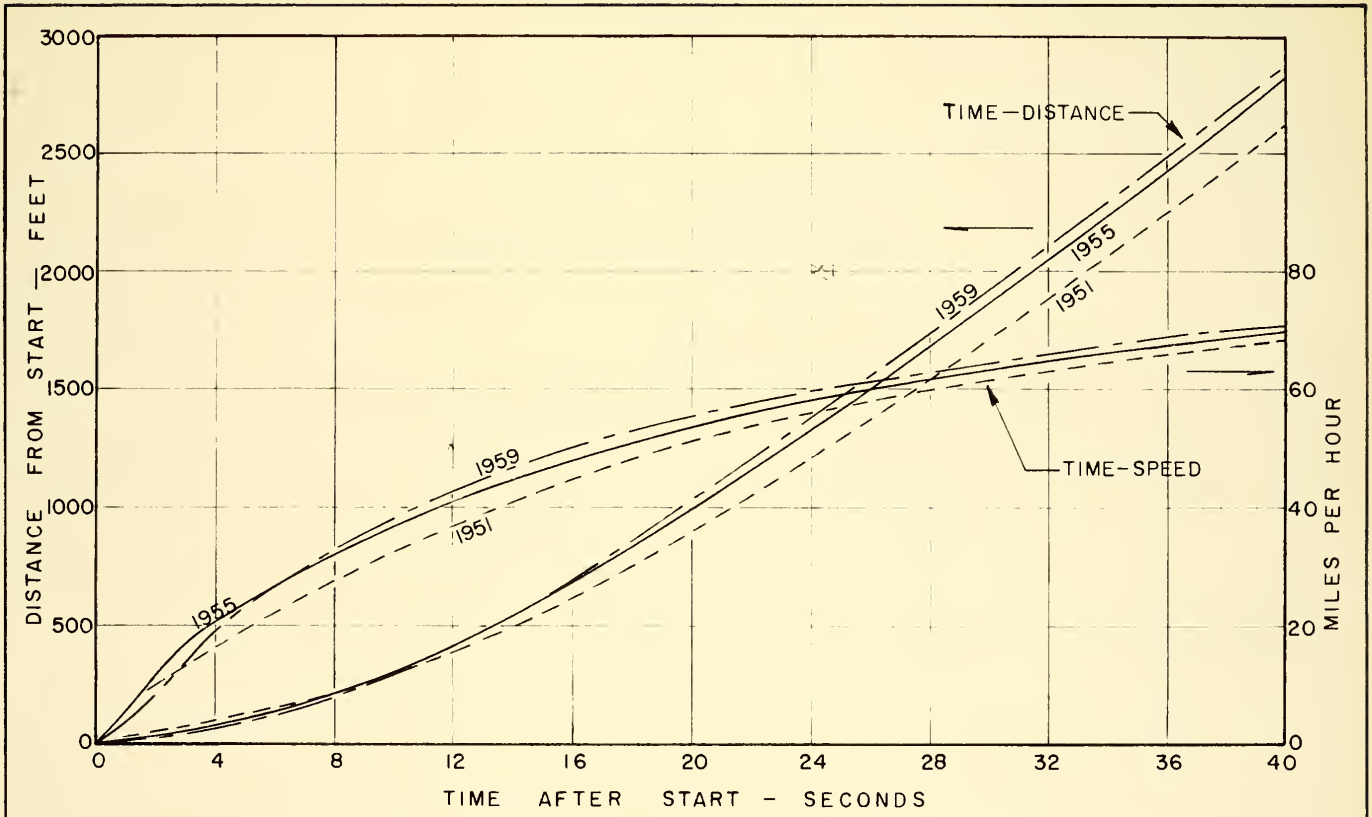

Figure 44 — Time-Distance and Time-Speed Comparison of the Poorest Performing Cars for Three Model Years (29)

PROPOSED STANDARD DECELERATION LANE

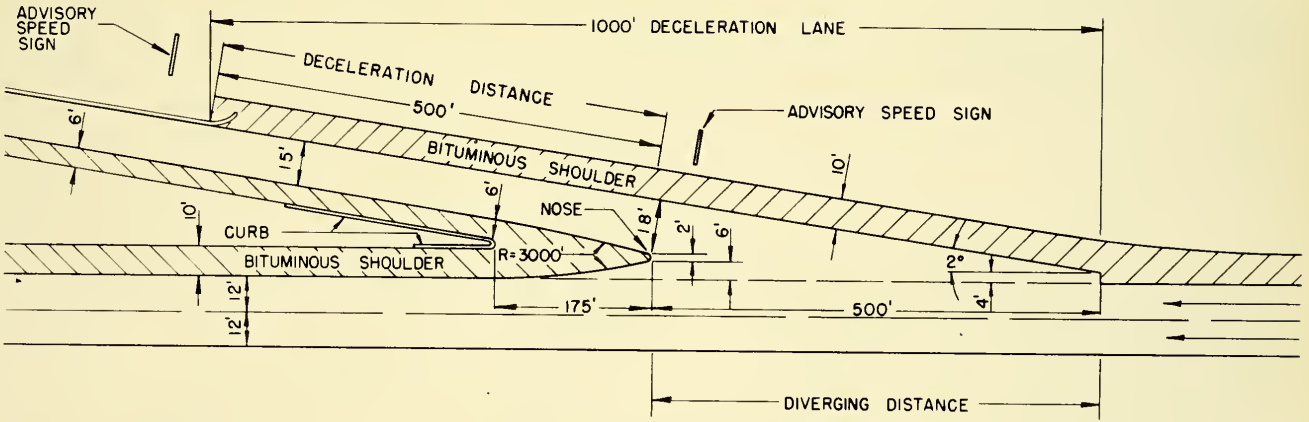

FIGURE 45